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(54) Title: CHIMERAS OF HEPATITIS C VIRUS AND BOVINE VIRAL DIARRHEA VIRUS (57) Abstract <p>Disclosed is a polynucleotide comprising a chimeric viral RNA which contains: a 5' nontranslated region (5' NTR), an open reading frame (ORF) region, and a 3' nontranslated region (3' NTR) wherein at least one of said regions is chimeric. The chimeric region comprises a first nucleotide sequence from a pestivirus in operable linkage with a heterologous nucleotide sequence. The chimeric viral RNA is replication-competent. Preferably the pestivirus sequence is from a bovine viral diarrhea virus and the heterologous nucleotide sequence is from a hepatitis C virus. Also disclosed are a method for identifying compounds having antiviral activity against hepatitis C virus, a genetically-engineered chimeric RNA virus and a vaccine against bovine viral diarrhea virus.</p>		

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Chimeras of Hepatitis C Virus and Bovine Viral Diarrhea Virus

Reference to Government Grant

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Related Applications

This application claims priority to, and incorporates herein in its entirety, U.S. 60/082,964 filed April 24, 1998.

10 Background of the Invention

(1) Field of the Invention

This invention relates generally to the development of therapies for treating hepatitis C virus (HCV) and bovine viral diarrhea virus (BVDV) and more particularly to the identification of such therapies using chimeric viruses comprising a genomic sequence derived from HCV and bovine viral diarrhea virus (BVDV).

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(2) Description of the Related Art

The *Flaviviridae* is an important family of human and animal RNA viral pathogens (Rice, CM. 1996. *Flaviviridae: The viruses and their replication*. In: Fields BN, Knipe DM, Howley PM., eds. *Fields virology*. Philadelphia: Lippincott-Raven Publishers. pp. 931-960.)

20 The three currently recognized genera of the *Flaviviridae* family exhibit distinct differences in transmission, host range, and pathogenesis. For example, members of the classical flavivirus genus, such as yellow fever virus and dengue virus, are typically transmitted to vertebrate hosts via arthropod vectors and cause acute self-limiting disease (Monath TP, Heinz FX. 1996. Flaviviruses. In: Fields BN, Knipe DM, Howley PM., eds. *Fields virology*. New York: Raven Press. pp. 961-1034). The pestiviruses, such as bovine viral diarrhea virus (BVDV) and classical swine fever virus (CSFV), cause economically important livestock disease and are spread by direct contact or the fecal-oral route (Thiel et al., 1996. Pestiviruses. In: Fields BN, Knipe DM, Howley PM., eds. *Fields virology*. New York: Raven Press. pp. 1059-1073). The most recently characterized *Flaviviridae* genus is the hepacivirus genus, the sole member

25 of which is the common and exclusively human pathogen, hepatitis C virus (HCV). HCV is

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transmitted by contaminated blood or blood products and is the most common agent of non-A, non-B hepatitis, affecting more than 1% of the population worldwide (Houghton, 1996. Hepatitis C viruses. In: Fields BN, Knipe DM, Howley PM., eds. *Fields virology*. Philadelphia: Lippincott-Raven Publishers. pp. 1035-1058.). Unlike flavivirus and pestivirus infections, which are usually eliminated by host immune response, chronic HCV infections are common and can cause mild to severe liver disease including cancer.

Despite these differences, members of the *Flaviviridae* family share common structural features and gene expression strategies. Virus particles consist of a lipid bilayer envelope with embedded transmembrane glycoproteins surrounding a protein-RNA nucleocapsid. Genome RNAs are single-stranded of positive polarity, and function as the sole mRNA species for translation of a single long open reading frame (ORF). This ORF is translated into a polyprotein which is processed by cellular and viral proteases into mature viral proteins. Structural proteins destined for incorporation into virus particles are encoded in the N-terminal portion of the polyprotein, while the nonstructural proteins which form components of the viral RNA replicase are encoded in the remainder.

Replication of the *Flaviviridae* RNA genome occurs via synthesis of a full-length negative-strand intermediate and is asymmetric, favoring synthesis of positive-strand RNAs. However, little is known about the details of this process. For all three genera of the *Flaviviridae* family, full-length functional cDNA clones have been constructed and RNAs transcribed from these cDNA templates are infectious. For flaviviruses and pestiviruses, mutagenesis of these clones and efficient RNA transfection of permissive cell cultures provides a means of probing the role of *cis* RNA elements and viral proteins in replicase assembly and function. Such analyses are not yet possible for HCV since this virus is unable to replicate efficiently in cell culture.

Like many other RNA viruses, it is believed the 5' and 3' terminal sequences of the *Flaviviridae* contain conserved *cis*-elements important for translation, RNA replication, and packaging (Bukh et al., *Proc. Natl. Acad. Sci. USA* 89:4942-4946, 1992; Deng et al., *Nucleic Acids Res.* 21:1949-1957, 1993; Cahour et al., *Viol.* 207:68-76, 1995; Kolykhalov et al., *J. Virol.* 70:3363-3371, 1996; Men et al., *J. Virol.* 70:3930-3937, 1996; Tanaka et al., *J. Virol.* 70:3307-3312, 1996; Huang HV. 1997. Evolution of the alphavirus promoter and the *cis*-acting sequences of RNA viruses. In: Saluzzo J-F, Dodet B. eds. *Factors in the emergence of arbovirus diseases*. Paris: Elsevier Press, pp. 65-79; Mandl et al., *J. Virol.* 72:2132-2140, 1998). The 5' nontranslated region (NTR) functions initially at the level of translation. Similar to most cellular mRNAs, flavivirus genome RNAs are translated in a cap-dependent manner. These RNAs contain a 5' cap structure that is presumably added by virus-encoded

RNA triphosphatases, guanylyl-, and methyl-transferases (Rice, 1996, *supra*). In contrast, the translational strategy employed by pestiviruses and HCV is more similar to that of the picornaviruses. These RNAs appear to be uncapped and contain long 5' NTRs with *cis* RNA elements that function as internal ribosome entry sites (IRES) for translation initiation at the polyprotein AUG (Lemon et al., *Semin. Virol.* 8:274-288, 1997).

The 5' NTRs of HCV and BVDV have a similar structural and functional organization despite containing only short stretches of high sequence identity (Wang et al., *Curr. Top. Microbiol Immunol.* 203:99-115, 1995; Lemon et al., 1997, *supra*). The IRES within each NTR is located at the 3' end of the NTR at a position proximal to the AUG initiation codon of the ORF. Although the 5' terminal sequence of each of these viruses is apparently not required for IRES function (Rijnbrand et al., *FEBS Lett* 365:115-119, 1995; Honda et al., *Virology.* 222:31-42, 1996; Rijnbrand et al., *J. Virol.* 71:451-457, 1997), these sequences are highly conserved among different strains of HCV (Bukh et al., *Proc. Natl. Acad. Sci. USA.* 89:4942-4946, 1992) or BVDV (Deng et al., 1993, *supra*), suggesting they play other roles in viral replication. For example, sequences in the 5' NTR may be required for regulating translation versus initiation of negative-strand RNA synthesis. Such regulation could occur by direct interaction of 5' and 3' RNA elements or indirectly, via RNA-protein interactions. Sequences in the 5' NTR may also modulate packaging versus translation. Finally, sequences complementary to the 5' NTR, which are located at the 3' end of negative-strand RNA, are likely to function in the initiation of positive-strand RNA synthesis.

The HCV 3' NTR contains an internal polypyrimidine tract followed by a highly conserved sequence of 98 bases at the 3' terminus, which has been shown to be required for replication of HCV (U.S. Application Serial No. 08/811,566).

Further elucidation of the role of sequences in the HCV 5' and 3' NTRs has been hampered by the inefficient replication of HCV in cell culture. This aspect of HCV biology also makes it difficult to identify and test possible antiviral compounds for activity against HCV. Thus, a need exists for a system which facilitates investigation of HCV replication and therapeutic approaches to control HCV infections.

30 Summary of the Invention

Briefly, therefore, the present invention provides novel compositions and methods for studying HCV replication which are based on the discovery that chimeras of HCV and BVDV genomic sequences can be constructed that are able to replicate in cell culture. The BVDV-specific sequence provides the chimeric viral nucleic acid with the ability to replicate in cell culture, while the HCV-specific sequence allows the chimeric viral nucleic acid to be used to

screen possible compounds for anti-viral activity against HCV. It is believed that similar replication-competent chimeras can be constructed from HCV and other pestiviruses.

Thus, in one embodiment, the present invention provides a novel, chimeric viral RNA in which at least one of the 5' NTR; ORF and 3' NTR regions is chimeric and comprises a nucleotide sequence from the corresponding region of a pestivirus in operable linkage with a nucleotide sequence from the corresponding region of an hepatitis C virus (HCV). The chimeric viral RNA is replication-competent. In preferred embodiments, the pestivirus is BVDV.

In other embodiments, the invention provides a polynucleotide comprising a DNA-dependent promoter operably linked to a cDNA of a chimeric viral RNA as described above and cells transiently transfected or stably transformed with the polynucleotide. In some embodiments the cDNA may encode a dominant selectable marker or an assayable reporter.

In yet another embodiment, the invention provides a method for identifying compounds having anti-HCV activity. The method comprises providing a first cell containing a chimeric viral nucleic acid derived from HCV and a pestivirus as described above and a second cell containing the pestivirus, and then comparing the replication efficiency of the chimeric viral nucleic acid in the presence and absence of a test compound to the replication efficiency of the pestivirus in the presence and absence of the test compound, wherein a greater reduction in compound-induced replication efficiency of the chimeric viral nucleic acid than the pestivirus indicates the compound has anti-HCV activity.

The invention also provides a genetically-engineered virus which comprises a chimeric viral nucleic acid derived from HCV and a pestivirus as described above. In one embodiment the genetically-engineered virus comprises virus particles containing at least one HCV structural protein and is useful in a vaccine against HCV. In another embodiment, the genetically-engineered virus is attenuated as compared to the pestivirus and is useful as a vaccine against the pestivirus.

In a still further embodiment, the invention provides a replication-competent BVDV vector expressing a heterologous sequence. The BVDV vector comprises the BVDV sequences encoding the BVDV replication machinery. In some embodiments, the replication-competent BVDV vector expresses an antigen and is useful as a vaccine.

Brief Description of the Drawings

Figure 1 is a schematic representation of the 5' NTRs of BVDV, HCV, and EMCV showing the position of the start codons of the ORF, and the boxes indicating the canonical IRES elements.

Figure 2 shows a schematic representation of BVDV and HCV chimeras, plaque phenotypes, reticulocyte translation efficiencies relative to parental BVDV, specific infectivities in MDBK cells, titers at 24 and 48 h post-transfection (or 72 h, as indicated), and an indication of whether pseudorevertants arose with results from BVDV, 5'HCV, BVDV+HCV, and BVDV+HCVdelB3 chimeras shown in Fig. 2A and results from BVDV+HCVdelB2B3, BVDV+HCVdelB1B2B3, BVDV+HCVdelB2B3H1, and BVDV+HCVdelB2B3H1H2 shown in Fig. 2B, where N.D. means not determined.

Figure 3 illustrates the *in vitro* translation efficiency of BVDV RNA or chimeras showing bar graphs of the amount of N^{pro}, the N-terminal protein in the BVDV ORF, expressed by the various constructs.

Figure 4 illustrates a schematic representation of EMCV chimeras, plaque phenotypes, reticulocyte translation efficiencies relative to parental BVDV, specific infectivities in MDBK cells, titers at 24 and 48 h post-transfection (or 72 h, as indicated), and an indication of whether pseudorevertants arose.

Figure 5 illustrates a pseudorevertant analyses showing in (Fig. 5A) the relative positions of mutations detected within the plaque-purified variants of passaged BVDV+HCVdelB1B2B3, 5'EMCV, and 5'HCV, and in (Fig. 5B) the 5' terminal sequences of pseudorevertants of BVDV+HCVdelB1B2B3, 5'EMCV, and 5'HCV. Novel nucleotides or sequences are shown in bold upper case type. Pseudorevertants are numbered and designated by the suffix ".R". The upper case sequence in BVDV+HCVdelB1B2B3 and BVDV+HCVdelB1B2B3.R1 is a remnant of downstream BVDV 5' NTR sequences and was created during the cloning procedures.

Figure 6 illustrates the construction of derivatives of 5'HCV designed to contain 5' termini corresponding to the sequence detected within the three analyzed pseudorevertants. Fig. 6A shows the 5' terminal sequence of the 5'HCV derivatives with the suffix (orig) designating a derivative containing the original 5' terminal sequence of the pseudorevertant; the suffix (cons) designating a derivative containing the consensus tetranucleotide sequence 5'-GUAU at the same position; and novel sequences shown in bold upper case type. Fig. 6B shows plaque phenotypes, reticulocyte translation efficiencies relative to parental BVDV, specific infectivities in MDBK cells, and titers at 24 and 48 h post-transfection are indicated.

Figure 7 illustrates a single step growth curve for various chimeric constructs showing released virus titers measured by performing plaque assays on MDBK cells transfected with various constructs.

Figure 8 illustrates replication of BVDV RNA or chimeric derivatives in transfected MDBK cells. Equal numbers of MDBK cells ($\sim 8 \times 10^6$) were electroporated with 5 μ g of

each *in vitro* synthesized RNA. MDBK cells were also transfected with infectious yellow fever 17D and Sindbis RNAs to provide molecular mass markers. One fifth of the transfected cells were seeded on 35-mm dishes and incubated in D-MEM supplemented with 10% horse serum for 6 h at 37°C. The media were then replaced with 1 ml of fresh media containing 2 g/ml of actinomycin D and 40 Ci/ml of ³H-uridine. Incubations were continued for 10 h at 37°C. RNAs were isolated as described in Materials and Methods, and 1/4 of the samples was denatured in glyoxal and loaded on an agarose gel. (A) Autoradiograph of the dried gel. Only the portion of the gel containing the genomic RNAs is shown. (B) Amount of radioactivity contained within the displayed fragments as determined by scintillation counting. BVDV, lane 1; 5'HCV, lane 2; BVDV+HCVdelB2B3, lane 3; BVDV+HCVdelB2B3H1, lane 4; 5'HCV.R1orig, lane 5; 5'HCV.R1cons, lane 6; 5'HCV.R3orig, lane 7; 5'HCV.R3cons, lane 8; 5'HCV.R2orig, lane 9; 5'HCV.R2cons, lane 10; yellow fever 17D, lane 11; Sindbis, lane 12; non-transfected MDBK cells, lane 13. The experiments shown is one of two repetitions which yielded similar results.

Figure 9 illustrates the genetic map of plasmid pACNR/BUD.

Figure 10 illustrates the sequence of low copy number plasmid pACNR/BVDV NADL (circular) harboring the functional cDNA of cytopathic BVDV NADL (positive sense cDNA 5' to 3'; nt 1-12578).

Figure 11 illustrates the sequence of infectious BVDV NADL (positive sense cDNA 5' to 3').

Figure 12 illustrates the sequence of infectious non-cytopathic BVDV NADL lacking cIns (positive sense cDNA 5' to 3').

Figure 13 illustrates the sequence adapted HCV 5' NTR from 5'HCV/R1.cons (positive sense cDNA 5' to 3'; only the sequence from the 5' base to the ATG initiating the polyprotein is shown).

Figure 14 illustrates the sequence of adapted HCV 5' NTR from 5'HCV/R1.orig (positive sense cDNA 5' to 3'; only the sequence from the 5' base to the ATG initiating the polyprotein is shown).

Figure 15 illustrates the sequence of adapted HCV 5' NTR from 5'HCV/R2.cons (positive sense cDNA 5' to 3'; only the sequence from the 5' base to the ATG initiating the polyprotein is shown).

Figure 16 illustrates the sequence of adapted HCV 5' NTR from 5'HCV/R2.orig (positive sense cDNA 5' to 3'; only the sequence from the 5' base to the ATG initiating the polyprotein is shown).

Figure 17 illustrates the sequence of adapted HCV 5' NTR from 5'HCV/R3.cons (positive sense cDNA 5' to 3'; only the sequence from the 5'base to the ATG initiating the polyprotein is shown).

Figure 18 illustrates the sequence of adapted HCV 5'NTR from 5'HCV/R3.orig (positive sense cDNA 5' to 3'; only the sequence from the 5' base to the ATG initiating the polyprotein is shown).

Figure 19 illustrates the sequence of prototype HCV-BVDV chimera from pNADL/5'HR3.orig/3'H3'B with the adapted HCV 5'NTR from 5'HCV/R3.orig and tandem 3' NTR elements from HCV followed by BVDV (positive sense cDNA 5' to 3') as discussed in Example 5.

Figure 20 illustrates various deletions of the poly U track in the 3'NTR HCV sequence of BVDV/HCV chimera p5H-3H33.

Figure 21 illustrates the schematic representation of functional HCV/-BVDV chimera from pCBV/p7.

Figure 22 illustrates the sequence of functional HCV-BVDV chimera from pCBV/p7 (positive sense cDNA 5' to 3').

Figure 23 illustrates the schematic representation of a HCV/BVDV chimera with selectable marker.

Figure 24 illustrates the sequence of functional HCV-BVDV chimera from pCBV/p7/IRES-pac expressing a dominant selectable marker conferring resistance to puromycin (positive sense cDNA 5' to 3').

Figure 25 illustrates the schematic representation of a bicistronic HCV/BVDV chimera.

Figure 26 illustrates the sequence of functional bicistronic chimera expressing the entire HCV structural region derived from plasmid pNADL/BI#41/HCV str (positive sense cDNA 5' to 3')

Description of the Preferred Embodiments

In accordance with the present invention, the inventors herein have succeeded in generating HCV-BVDV chimeric RNAs which are replication competent. Such chimeras are useful in screening compounds *in vitro* for antiviral activity against HCV. In addition, it is believed that *in vivo* replication of HCV-BVDV chimeras according to the invention may be attenuated as compared to wild-type BVDV and thus may be useful in vaccinating animals against BVDV. It is also believed that the HCV chimeric structures described herein for BVDV are applicable to other pestiviruses.

In the context of this disclosure, the following terms will be defined as follows unless otherwise indicated:

"Cis-acting sequences" means the nucleotide sequences from an RNA virus genome that are necessary for recognition of the genomic RNA by specific protein(s) of the RNA virus or host cell that carry out replication, transcription, translation or packaging of the genome.

"Genetically-engineered virus" means any virus whose genome is different than that of a wild-type virus due to a human-made deletion, insertion, or substitution of one or more nucleotides to the wild-type viral genome.

"Infectious" when used to describe a virus means the virus is capable of entering cells and initiating a virus replication cycle, whether or not this leads to the production of new RNA virus particles.

"Nucleotide sequence" as used herein refers to DNA and the corresponding RNA sequence where relevant. It will be understood that sequences shown in the Figures are DNA versions of the RNA sequence and that chimeric molecules of the invention may comprises RNA molecules or cDNA copies of such RNA molecules.

"Replication-competent" as applied to a chimeric HCV-pestivirus RNA means the RNA is capable of RNA-dependent replication in at least one cell type that supports replication of the wild-type parental pestivirus. The number of replicated RNA molecules produced by an HCV-pestivirus chimeric RNA of the invention is at least 10-fold higher than the limit of detection, which is typically 10 to 100 molecules. More preferably, chimeric RNA production by the HCV-pestivirus chimeric RNA is at least 10^2 to 10^3 -fold higher than the detection limit. The replication-competent chimeric RNA replicates at an efficiency that is preferably, at least 0.001%, more preferably, at least 0.01%, more preferably, at least 0.1%, more preferably, at least 1%, more preferably at least 10% and most preferably at least 50% up to 90% that of the parental pestivirus in the same cell type.

"Transfected cell" means a cell containing an exogenously introduced nucleic acid molecule, and includes cells that are transiently transfected with the exogenous nucleic acid.

"Transformed cell" or "stably transformed cell" means a cell containing an exogenously introduced nucleic acid molecule which is present in the cytoplasm or nucleus of the cell and may be stably integrated into the chromosomal DNA of the cell.

"Virus" means a virion, virus particle or a viral genome.

A chimeric viral RNA according to the invention is designed to comprise a 5' NTR, an ORF, and a 3' NTR, at least one of which is a chimeric region containing two operably linked nucleotide sequences that are from the same region of a pestivirus and an HCV.

Pestivirus-specific sequences useful in the invention can be taken from the appropriate genomic region of any cytopathic or noncytopathic type I or type II BVDV isolate, classical swine fever virus (CSFV) isolate, or border disease viral isolate. For a list of pestiviruses, see Thiel, H.-J., P. G. W. Plagemann, and V. Moennig. 1996. Pestiviruses, p. 1059-1073. In B. N. Fields, D. M. Knipe and P. M. Howley (ed.), Fields Virology. Raven Press, New York. HCV-specific sequences can be taken from any strain or isolate of HCV, including but not limited to HCV-1, HCV-1a, HCV-1b, HCV-1c, HCV-2a, HCV-2b, HCV-2c, HCV-3a. Preferably, the parental pestivirus is a cytopathic strain of BVDV and the parental HCV strain is HCV-1.

10 The pestivirus- and HCV-specific sequences are operably linked in the chimeric region, meaning the sequences are arranged such that the resulting chimeric structure is functional in the context of replication of the pestivirus. For example, in one preferred embodiment the chimeric viral RNA comprises a chimeric 5' NTR which comprises a BVDV-specific 5' terminal sequence of 5'-(G/A)UAA and an IRES derived from HCV, with
15 the ORF and the 3' NTR consisting of a sequence from the same regions of BVDV. The BVDV-specific sequences at the 5' terminus and in the ORF and 3' NTR are chosen such that they are functional in the context of BVDV, meaning the chimeric viral RNA expresses the replication machinery of BVDV and this replication machinery is capable of replicating the chimeric RNA. In addition, translation of the BVDV ORF in the chimeric viral RNA is
20 dependent upon a functional HCV IRES. The presence of a functional HCV IRES in this chimera allows the chimera to be used to screen for compounds that target the HCV IRES and thereby inhibit translation of the BVDV ORF as well as replication of the chimeric virus. Such compounds would be expected to also inhibit translation of the ORF in a wild-type HCV and consequently inhibit HCV replication.

25 Compounds that could be screened for anti-HCV activity using this and other HCV-BVDV 5' NTR chimeras include but are not limited to antisense RNAs, RNA decoys that bind proteins involved in recognition of the HCV-specific sequences, ribozymes, and small molecule inhibitors of critical RNA-protein interactions. The use of such substances for therapeutic applications are known in the art. See, e.g., Amarzguioui M, et al., "Hammerhead
30 ribozyme design and application." *Cell Mol Life Sci.* 1998 Nov;54(11):1175-202; Welch PJ, et al., "Expression of ribozymes in gene transfer systems to modulate target RNA levels.", *Curr Opin Biotechnol.* 1998 Oct;9(5):486-96; Bramlage B, et al. "Designing ribozymes for the inhibition of gene expression."; *Trends Biotechnol.* 1998 Oct;16(10):434-8; Gewirtz AM, et al. "Nucleic acid therapeutics: state of the art and future prospects."; *Blood.* 1998 Aug
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- 30 trans-activator." *Proc Natl Acad Sci U S A.* 1992 Oct 15;89(20):9870-4.

It is contemplated that a number of replication-competent chimeric structures can be made that allow the function of various HCV sequence elements and proteins to be studied and targeted in drug screening assays. For example, the invention includes replication-competent HCV-pestivirus chimeras having a chimeric ORF. One such chimeric ORF is one

35 comprising an HCV sequence encoding the structural proteins and a pestivirus sequence

encoding the nonstructural proteins. It is believed that upon introduction into a cell, such a HCV-BVDV ORF chimera will produce HCV-like virus particles that will be released from the cell and capable of infecting cells normally infected by wild-type HCV, i.e., cells expressing an HCV receptor such as human CD81. Such ORF chimeras would be useful to screen compounds for drugs that inhibit formation, release or entry of HCV particles. In addition, ORF chimeras that produce virus particles containing at least one HCV structural protein would be useful as vaccines against HCV. Other ORF chimeras contemplated by the invention include, for example, chimeras comprising a pestivirus sequence encoding structural proteins and an HCV sequence encoding one or more nonstructural proteins such as the NS3 protease, NS4A cofactor, NS5A phosphoprotein/interferon resistance determinant and/or the NS5B polymerase. Replication of such ORF chimeras would be dependent upon the function of the HCV nonstructural protein(s) and these ORF chimeras could be used to screen for drugs that target the HCV nonstructural protein(s) as well as to screen for and map potential drug resistance mutations in HCV nonstructural proteins. In addition, HCV-pestivirus ORF chimeras could be useful for developing alternative *in vivo* animal models for HCV replication and HCV-associated hepatocellular carcinoma to evaluate antivirals and anti-tumor agents.

The invention also provides replication-competent HCV-pestivirus chimeras having a chimeric 3' NTR which contains one or more conserved elements of the HCV 3' NTR. Such 3' NTR chimeras would be useful for screening or evaluating compounds targeted against the HCV 3' NTR. Compounds that could be screened include antisense RNA molecules, ribozymes and small molecule inhibitors of critical RNA-protein interactions. One 3' NTR chimera according to the invention comprises a BVDV 5' NTR, BVDV ORF and a chimeric 3' NTR which consists of an HCV-specific sequence derived from the HCV 3' NTR immediately followed by a BVDV 3' NTR. The HCV-specific 3' NTR that allows for replication in the context of BVDV has a deletion in the 3' NTR poly (U) tract but has all the other HCV 3' NTR elements, including the 98 bp 3' terminal conserved element.

HCV-pestivirus chimeras included within the scope of the invention include those comprising combinations of chimeric regions, i.e., 5' NTR and ORF chimeras; 5' NTR and 3' NTR chimeras; ORF and 3' NTR chimeras; and chimeric RNAs in which each of the 5' NTR, ORF and 3' NTR regions comprise an HCV sequence operably linked to a pestivirus sequence.

The invention also provides chimeric RNAs having two ORFs, or bicistronic HCV-pestivirus chimeras. Bicistronic chimeras contemplated by the invention include structures in which the first ORF contains one or more HCV genes and is followed by a second IRES

operably linked to a second ORF encoding the pestivirus replicase machinery. It is also contemplated the first ORF may encode a heterologous sequence such as an antigen.

It is believed that many HCV-pestivirus chimeras of the invention will be attenuated as compared to the parental wild-type pestivirus. Such attenuated chimeric RNA genomes
5 would be candidate vaccines in the form of live-attenuated virus particles or as RNA or cDNA "genetic" vaccines.

The invention also includes vaccines against HCV which comprise an immunogenically-effective amount of HCV-pestivirus particles or nucleic acid. Anti-HCV vaccines comprising virus particles should preferably contain one or more HCV structural
10 proteins.

The therapeutic or pharmaceutical compositions of the present invention can be administered by any suitable route known in the art including for example by injection such as intraperitoneal, intravenous, subcutaneous, intramuscular, transdermal, intrathecal or intracerebral injection. Administration can be either rapid as by injection or over a period of
15 time as by slow infusion or administration of slow release formulation.

Compositions according to the invention can be employed in the form of pharmaceutical or veterinary preparations. Such preparations are made in a manner well known in the pharmaceutical and veterinary arts. One preferred preparation utilizes a vehicle of physiological saline solution, but it is contemplated that other pharmaceutically acceptable
20 carriers such as physiological concentrations of other non-toxic salts, five percent aqueous glucose solution, sterile water or the like may also be used. It may also be desirable that a suitable buffer be present in the composition. Such solutions can, if desired, be lyophilized and stored in a sterile ampoule ready for reconstitution by the addition of sterile water for ready injection. The primary solvent can be aqueous or alternatively non-aqueous.

25 The carrier can also contain other pharmaceutically-acceptable excipients for modifying or maintaining the pH, osmolarity, viscosity, clarity, color, sterility, stability, rate of dissolution, or odor of the formulation. Similarly, the carrier may contain still other pharmaceutically-acceptable excipients for modifying or maintaining release or absorption or penetration across the blood-brain barrier. Such excipients are those substances usually and
30 customarily employed to formulate dosages for parenteral administration in either unit dosage or multi-dose form or for direct infusion into the cerebrospinal fluid by continuous or periodic infusion.

It is also contemplated that certain formulations containing a chimeric virus according to the invention are to be administered orally. Such formulations are preferably encapsulated
35 and formulated with suitable carriers in solid dosage forms. Some examples of suitable

carriers, excipients, and diluents include lactose, dextrose, sucrose, sorbitol, mannitol, starches, gum acacia, calcium phosphate, alginates, calcium silicate, microcrystalline cellulose, polyvinylpyrrolidone, cellulose, gelatin, syrup, methyl cellulose, methyl- and propylhydroxybenzoates, talc, magnesium, stearate, water, mineral oil, and the like. The formulations can additionally include lubricating agents, wetting agents, emulsifying and suspending agents, preserving agents, sweetening agents or flavoring agents. The compositions may be formulated so as to provide rapid, sustained, or delayed release of the active ingredients after administration to the patient by employing procedures well known in the art. The formulations can also contain substances that diminish proteolytic degradation and promote absorption such as, for example, surface active agents.

The specific dose is calculated according to the approximate body weight or body surface area of the patient or the volume of body space to be occupied. The dose will also be calculated dependent upon the particular route of administration selected. Such calculations can be made without undue experimentation by one skilled in the art. Exact dosages are determined in conjunction with standard dose-response studies. It will be understood that the amount of the composition actually administered will be determined by a practitioner, in the light of the relevant circumstances including the condition or conditions to be treated, the choice of composition to be administered, the age, weight, and response of the individual patient, the severity of the patient's symptoms, and the chosen route of administration. Dose administration can be repeated depending upon the pharmacokinetic parameters of the dosage formulation and the route of administration used.

Replication-competent HCV-pestiviruses are generated by choosing the HCV function or sequence element desired to be studied. The HCV sequence can be obtained from a plasmid clone of a partial or full HCV genome using PCR to amplify a target region containing the desired sequence or by restriction enzyme digestion. The HCV fragment is then inserted into the desired location of a clone of the pestivirus genome using standard techniques. Desired portions of the pestivirus genome may be deleted before or after addition of the HCV fragment. The recombinant genome is then transfected into a cell that supports replication of the parental pestivirus genome and their ability to replicate using standard assays. For example, replication can be assessed by virus-induced cytopathic effect; plaque formation; detection of viral antigens and/or viral RNA accumulation; and by plaque assay measuring released infectious virus. The inventors herein have found that the BVDV RNA replication machinery works in many cell types, including bovine, hamster, mouse and human cells. It has also been reported that BVDV RNAs can amplify in other cell types including human hepatoma lines and hepatocytes (Behrens SE, et al., *J Virol.* 1998 Mar;72(3):2364-72).

The host cell range for a particular chimera will be dependent upon the properties of that chimera as empirically determined.

As described below, some chimeras do not replicate stably as indicated by heterogeneity in the size of plaques produced by the chimeric virus. Upon passage, pseudorevertants can frequently be isolated that are capable of stable replication. Such pseudorevertants will have one or more deletions or base substitutions in the HCV and/or pestivirus sequences. Information derived from these gain-of-function mutations can be used to define the elements necessary for generating stable, replication-competent chimeras of HCV and a pestivirus.

The invention provides a method for screening compounds for antiviral activity against HCV. The method involves comparing a test compound's effect on replication of a chimeric HCV-pestivirus RNA molecule as described above with the compound's effect on replication of the parental pestivirus. Compounds which have a greater effect on replication of the chimeric virus than the pestivirus are likely directed against the HCV portion of the chimera. Typically, the method is performed by providing duplicate cell cultures containing a chimeric viral RNA which is replication-competent in that cell, treating one of the culture with the test compound, and then measuring the replication efficiency of the chimeric RNA in both cultures. Any effect induced by the compound is compared against the compound's effect on replication of the parental pestivirus in cells of the same type. This control assay is preferably performed at the same time using the same culture conditions.

The cells used in the screening assay can be prepared by transiently transfecting the cells with the desired chimeric RNA molecule as described below. Alternatively, it is contemplated that the chimeric RNA molecule can be constitutively expressed in the cell by transfecting the cell with a polynucleotide comprising a cDNA of the chimeric RNA operably linked to a DNA-dependent promoter. The chimeric cDNA may include a selectable marker which would allow for selection of cells expressing the chimeric RNA. It is also envisioned the selectable marker could be a dominant marker that allows selection of cells expressing chimeras having adaptive mutations or selection of cells permissive for virus replication (Frolov et al., *J. Virol.* 73:3854-3865, 1999). It is also contemplated the cDNA could express a reporter gene that could be assayed to measure RNA replication.

Alternatively, chimeric virus particles are incubated with a cell permissive for infection by the pestivirus in the presence or absence of the test compound and then replication of the chimeric virus is measured and compared to the replication of the parental pestivirus incubated with the same cell type in the presence or absence of the test compound.

Inhibition of replication can be measured in many ways, including assaying for the reduction of virus-induced cytopathic effect; inhibition of plaque formation, reduced production of viral antigens as detected by immunofluorescence assay; reduced viral RNA accumulation; reduction in released infectious virus from treated and untreated control and chimera samples using a plaque assay. In addition, it is contemplated that a cell line that is designed for pestivirus-specific transactivation of a reporter gene could be used directly or in lieu of a plaque assay. The reporter gene is operably linked to a promoter that is activated upon infection by the chimeric virus and production of the viral transactivator protein.

Preferred embodiments of the invention are described in the following examples. Other embodiments within the scope of the claims herein will be apparent to one skilled in the art from consideration of the specification or practice of the invention as disclosed herein. It is intended that the specification, together with the examples, be considered exemplary only, with the scope and spirit of the invention being indicated by the claims which follow the examples.

Example 1

This example illustrates the construction and analysis of 5' HCV-BVDV chimeras as reported in detail in Frolov et al. (*RNA* 4:1418-1435, 1998) which is incorporated in its entirety by reference. A functional clone of BVDV (Mendez et al., *J. Virol.* 72:4737-4745, 1998) was used to construct and characterize a series of 5' NTR chimeras with sequences derived from HCV and the picornavirus, encephalomyocarditis virus (EMCV). The results help to define the requirements of a functional BVDV 5' NTR and provide replication-competent BVDV-HCV chimeras dependent on a functional HCV IRES.

Example 2

This example illustrates the construction of chimeras for expressing additional functional portions of the HCV genome by addition of further HCV sequence downstream from the functional or adapted HCV 5'NTR chimeras fused in-frame to the BVDV ORF.

One such construct (Figure 21) involves fusion of HCV sequences to BVDV sequences in the p7 protein coding region (at a convenient BseRI restriction site). Both HCV and BVDV encode a p7 protein that is located immediately downstream of the E2 protein. The p7 protein is a small hydrophobic protein of unknown function. pCBV/p7 consists of the first 79 bases of the BVDV 5'NTR encoding stem loop structure B1' and B1, followed by the entire HCV 5'NTR, the entire HCV structural protein coding region and the first 36 amino acids of HCV p7 fused to the C-terminal 31 amino acids of BVDV p7. The fused p7 gene is followed by the remainder of the BVDV ORF including the entire nonstructural region and the BVDV 3' NTR. Transfection of MDBK cells with the RNA corresponding to this

sequence (Fig. 22) leads to replication of the chimeric RNA and production of the expected HCV and BVI polyprotein cleavage products. Variations on this strategy are envisioned in which all or part of the HCV polyprotein and cis elements important for RNA packaging can be expressed in viable chimeras. In addition the BVDV replicase regions for either cytopathic or non-cytopathic pestiviruses (like NADL cIns-) can be used. Transfection of cells permissive for HCV particle, assembly, release and reinfection with this chimeric RNA can be used to make HCV-like particles. These particles and this infection system can be used (i) to screen for specific inhibitors of HCV particle, assembly, release and reinfection, (ii) for identifying antibodies capable of neutralizing HCV infectivity and (iii) as live or inactivated vaccines. Furthermore, this embodiment of the invention demonstrates that the BVDV RNA replication machinery can be used for expression of heterologous RNA and polypeptide sequences and can be used as a vehicle for RNA or DNA "genetic" vaccination in which the BVDV replicase amplifies the level of antigen expression by cytoplasmic RNA-dependent replication.

15

Example 3

This example illustrates chimeric RNA's that are modified to express dominant selectable markers, assayable markers or FACS sortable markers.

Such variants can be used to select for chimeras capable of replication in particular cell types, or to screen for cell types that are permissive for replication of the chimeric RNA. Selectable markers include, but are not limited to, the genes encoding puromycin resistance (puromycin N-acetyl transferase; PAC), neomycin resistance, blasticidin resistance, hygromycin resistance, etc. Assayable markers include, but are not limited to, the genes encoding B-galactosidase, luciferase, B-glucuronidase, etc. Easily sortable molecules include single chain antibodies, cell surface markers, and non-toxic protein markers like green fluorescent protein. In a specific example (Figures 23 and 24), the RNA encoded by pCBV/p7 was modified to include a cassette at the beginning of the BVDV 3'NTR that is comprised of the EMCV IRES driving the gene encoding PAC. This chimeric RNA can replicate, expresses PAC and confers resistance to puromycin resistance. This property can be used to select for variants of the chimera that are capable of noncytopathic replication in desired cells type and also provides a means of showing that cells harbor a functional chimeric RNA. Desired variants can be identified, cloned and further characterized as described in Example 1. Of note, is that this location in the BVDV genome and this strategy for expressing heterologous genes may also be applied to using infectious attenuated

pestiviruses as gene expression vectors and as chimeric live vaccines against other animal pathogens.

Example 4

5

This example illustrates the use of the bicistronic strategy as an alternative to the in-frame fusions described in Example 2.

A specific example is shown in Figure 25 and its sequence as Figure 26. In this bicistronic chimera, the 5' sequences are identical to that of pCBV/p7 except that the HCV
10 ORF continues to include the first 246 amino acids of NS4B. The HCV sequence is followed by the EMCV IRES fused to BVDV Npro, the N-terminal 10 aa of BVDV C, the C-terminal 19 aa of C, 9 N-terminal amino acids of Erns, 48 C-terminal amino acids of E2 and the remainder of the BVDV NADL ORF and 3' NTR. The constructed BVDV ORF encodes a
15 functional BVDV RNA replicase. The deletions in the N-terminal portion of this ORF were designed to preserve proper membrane topology and processing of the replicase. The bicistronic chimeric RNA can replicate upon transfection of permissive BVDV host cells.

Example 5

20 This example illustrates 3'NTR chimeras. Although initial attempts to recover viable chimeric viruses in which the BVDV 3'NTR was completely replaced by that of HCV were unsuccessful, a strategy similar to that detailed in Example 1 has produced chimeras that harbor the conserved elements of the HCV 3'NTR. An initial tandem 3'NTR construct was made in which the HCV 3'NTR was engineered to follow the BVDV ORF. The complete
25 BVDV 3'NTR was position 3' to the HCV 3' NTR after a short heterologous sequence. This sequence of this parental construct, which replicated poorly, is shown in Figure 19. RNAs transcribed from this plasmid were of low specific infectivity suggesting that revertants or pseudorevertants might have arisen. Indeed isolation and sequence analysis of several independent plaque-forming variants revealed that deletions in the HCV poly U tract of
30 various lengths had occurred. These revertant sequences are shown in Figure 20. When these altered HCV 3'NTRs were reconstituted into the original tandem 3' NTR parent, they gave rise to plaque forming RNA transcripts of high specific infectivity, demonstrating that these alterations restored the ability of the chimeric RNA to replicate. Large deletions in the U tract gave rise to virus with more robust replication and larger plaques while stably maintaining the
35 conserved HCV 3'NTR 98-base element and the polypyrimidine "transition" region. Such

chimeric viruses can now be used to screen and evaluate antisense, ribozyme, and other therapeutics targeted against this conserved HCV RNA element that is essential for replication.

5

Materials and Methods

Plasmid Constructs

pACNR/BVDV NADL was previously described (Mendez et al., 1998, *supra*). pBVDV is a derivative of pACNR/BVDV NADL which contains a G→T transversion at nt 14994 that creates an *Xba* I site upstream of the T7 promoter (T. Myers & C.M. Rice, unpubl.). To facilitate construction of the chimeras, subclones were created. First, two fragments were isolated by PCR amplification of p90/HCVFLlongpU (Kolykhalov et al., *Science* 277:570-574, 1997) with primers #498 (5'-TGTACATGGCACGTGCCAGCCCC) and #498 (5'-GATCAACTCCATGGTGCACGGTCT) and pBVDV with primers #481 (5'-AGACCGTGCACCATGGAGTTGATC) and #482 (5'-CGTTTCACACATGGATCCCTCCTC). These two fragments were digested with *Apa* I and ligated to produce a fragment containing a fusion of the HCV 5' NTR to the BVDV ORF. This fragment was digested with *Sac* I and ligated into pGEM3Zf(-) which had been digested with *Sma* I and *Sac* I to produce the subclone pGEM498-*Sac* I. Next, a fragment containing the BVDV 5' NTR was synthesized by PCR amplification of pBVDV with primers #183 (5'-TTTTCTAGATAATACGACTCACTATAGTATACGAGAATTAGAAAAGGCACTCG) and #480 (5'-GGGGGCTGGCACGTGCCATGTACA). This fragment was digested with *Xba* I and *Bsr* G I and ligated into pGEM498-*Sac* I digested with the same two enzymes, to create the plasmid pGEMXbal-*Sac* I. pGemXbal-*Sac* I contains a tandem fusion of the BVDV 5' NTR, the HCV 5' NTR, and the 5' portion of the BVDV N^{pro} gene. pBVDV + HCV was created by digesting pGEMXbal-*Sac* I with *Xba* I and *Sac* I and ligating the fragment into pBVDV digested with the same two enzymes, and as such pBVDV + HCV contains the T7 promoter, followed by the entire 385-nt 5' NTR of BVDV, a GT dinucleotide (nt 386-387), the entire 341-nt 5' NTR of HCV (nt 388-728), and the sequence of the BVDV NADL strain including the ORF and 3' NTR. Derivatives of pBVDV + HCV containing deletions within the BVDV 5' NTR and/or the HCV 5' NTR were created in the subclone pGEMXbal-*Sac* I, as described below, prior to ligation into *Sba* I- and *Sac* I-digested pBVDV. For making deletions, restriction sites with non-compatible protruding ends were treated with the Klenow fragment of DNA polymerase I prior to ligation. For creation of pBVDV + HCVdelB3 (deletion of nt 174-374, inclusive), pGEMXbal-*Sac* I was digested with *Afl* II and *Bsr* G I. For pBVDV + HCVdelB2B3 (deletion of nt 67-374), pGEMXbal-*Sac* I was digested

with *Avr* II and *Bsr*GI. For pBVDV + HCVdelB1B2B3 (deletion of nt 33-374), pGEMXbal-SacI was digested with *Sna*B I and *Bsr*GI. For pBVDV + HCVdelB2B3H1 (deletion of nt 67-3396), pGEMXbal-SacI was digested with *Avr* II and *Xcm* I. For pBVDV + HCVdelB2B3H1H2 (deletion of nt 67-513), pGEMXbal-SacI was digested with *AVR* II and *Bsg* I. For pBVDV + HCVdelB2B3H3 (deletion of nt 67-374, 518-704), subclone pGEMXbal-SacI delB2B3 was digested with *Sma* I. p5'HCV was created by digesting p90/HCVliongpU with *Xba* I and *Nru* I and ligating the fragment into pBVDV + HCV digested with the same two enzymes.

The EMCV plasmid, pEC_g, was provided by Ann Palmenberg and is described elsewhere (Hahn et al., *J. Virol* 69:2697-2699, 1995). p5'EMCV contains the entire 710 nt of the 5' NTR of EMCV, followed by the open reading frame of BVDV and the 3' NTR. One extra G residue was added between the T7 promoter and the first nucleotide of the EMCV 5' NTR to facilitate efficient in vitro transcription. Convenient restriction sites within the BVDV 5' NTR or the EMCV 5' NTR were used to create additional chimeras. Sites with noncompatible protruding ends were treated with the Klenow fragment of DNA polymerase I prior to ligation. For example, the plasmid pBVDV + EMCVdelA contains nt 1-378 of BVDV 5' NTR fused with nt 45-710 of EMCV (the *Bsr*GI site of BVDV ligated to the *Eco*R V site of EMCV), pBVDV + EMCVdelB3A contains nt 1-173 of BVDV fused with nt 45-710 of EMCV (the *Afl* II site of BVDV ligated to the *Eco*R V site of EMCV). pBVDV + EMCVdelB2B3A contains nt 1-66 of BVDV fused with nt 45-710 of EMCV (the *Avr* II site of BVDV ligated to the *Eco*R V site of EMCV). pBVDV + EMCVdelB3ABC contains nt 1-173 of BVDV fused with nt 161-710 of EMCV (the *Afl* II site of BVDV ligated to the *Psp*1405 site of EMCV). pBVDV + EMCVdelB2B3ABC contains nt 1-66 of BVDV fused with nt 161-710 of EMCV (the *Avr* II site of BVDV ligated to the *Psp*1406 site of EMCV). pBVDV + EMCVdelB3A-H contains nt 1-101 of BVDV fused with nt 289-710 of EMCV (the *Nhe* I site of BVDV ligated to the *Avr* II site of EMCV). pBVDV + EMCVdelB2B3A-H contains nt 1-62 of BVDV fused with nt 289-710 of EMCV (the *Avr* II site of BVDV ligated to the *Avr* II site of EMCV). The schematics of the chimeric 5' NTRs are presented in Figures 2 and 4.

All other heterologous 5' NTRs used in the study were generated by PCR using an oligonucleotide complementary to nt256-272 of the HCV 5' NTR and primers containing the sequence of the *Xba* I restriction site followed by the T7 promoter, the heterologous sequences found in sequenced pseudorevertants, or sequences corresponding to different regions of the HCV 5' NTR. All the fragments were subcloned into the plasmid, pRS2 (a derivative of pUC19), sequenced, and recloned into the p5'HCV plasmid by replacing the

fragment between the *Xba* I site located upstream of the T7 promoter and the *Nhe* I site (nt 249-254) in the 5' NTR of HCV.

Cell cultures

5 MDBK cells were obtained from M. Collett (ViroPharma, Inc.) and BT cells were obtained from the American Type Culture Collection (Rockville, Maryland). Cells were grown in Dulbecco's modified Eagle medium (D-MEM) supplemented with 10% horse serum and sodium pyruvate.

Transcriptions and transfections

10 All the designed plasmids, including pBVDV and the chimeric derivatives, were digested to completion with *Sda* I (*Sse*83871), purified by phenol extraction, precipitated by ethanol, and dissolved in water. The transcription reactions were performed in the T7 Megascript kit (AMBION) using the conditions recommended by the manufacturer. Reactions were incubated at 37°C for 1 h, and ³H-UTP was added to the reaction to quantify the RNA synthesis. The quality of the synthesized RNAs was checked by agarose gel
15 electrophoresis, and samples containing 50-60% of full-length RNA were used for electroporations and in vitro translations. The reaction mixtures were aliquoted and stored at -70°C prior to electroporation or in vitro translations.

Transfection was performed by electroporation of MDBK cells using previously described conditions (Mendez et al., 1998, *supra*). Two micrograms of in vitro synthesized
20 RNA, corresponding to approximately 1 µg of the full-length transcript, were used per electroporation. In standard experiments, ten-fold dilutions of electroporated cells were seeded in 6-well tissue culture plates containing 5 x 10⁵ naive MDBK cells per well. After 1 h of incubation at 37°C in a 5% CO₂ incubator, cells were overlaid with 3 ml of 0.6% LE Sea Kem agarose (FMC Bioproducts) containing minimal essential medium supplemented
25 with 5% horse serum. Plaques were stained with crystal violet after 3 days incubation at 37°C. The rest of the transfected cells was seeded into 100-mm dishes and incubated for approximately 48 h or until cytopathic effect was observed in virtually all cells. Samples of the media were taken at 24 and 48 h, and virus titers were determined as described above and previously (Mendez et al., 1998, *supra*).

30 Analysis of the 5' ends of viral genomes

Sequencing of the 5' ends of selected variants of BVDV was performed on plaque-purified viruses. Plaques were typically isolated from the agarose overlay without staining with neutral red. Virus was eluted in 1 ml of D-MEM/10% horse serum for several hours and was used to infect 5 x 10⁵ MDBK cells in 35-mm dishes. After 1 h of virus adsorption of 37

°C, an additional 1 ml of D-MEM/10% horse serum was added to the dishes, and incubation was continued for 36-48 h until cytopathic effect was observed in virtually all cells.

Fifty microliters of harvested viral stocks were clarified by low speed centrifugation, and viral RNAs were isolated by TRIzol reagent (Gibco-BRL) using the protocol recommended by the manufacturer. Sequencing of the 5' termini was performed using an oligonucleotide/cDNA-ligation strategy described elsewhere (Troutt et al., *Proc. Natl. Acad. Sci. USA* 89:9823-9825, 1992). The primer S1 (5'-GTCGTTTCACACATGGATCC), complementary to nt 710-729 of the BVDV genome, was used for cDNA synthesis. A phosphorylated oligonucleotide tag (5'-GACTGTTGTGGCCTGCAGGGCCGAATT) with an amino group on the 3' terminus was ligated to the first strand cDNA (Troutt et al., 1992, *supra*). One tenth of this reaction mixture was used for PCR amplification. The primers for PCR amplification were as follows: primer A (5'-GCCCTGCAGGCCACAACAGTC), complementary to the tag; primer B (5'-TCAGGCAGTACCACAA) complementary to nt 281-296 of the HCV 5' NTR; and primer C (5'-GGAATGCTCGTCAAGAAGACAG), complementary to nt 268-289 of the EMCV 5' NTR. The primer pairs of A + B or A + C were used for analysis of the pseudorevertants of 5'HCV and BVDV + HCVdelB1B2B3 or 5'EMCV, respectively. For the 5'HCV pseudorevertants, one tenth of the ligation mixture was used for an additional PCR reaction. This fragment was synthesized using primer S1, describe above, and a primer corresponding to nt 147-175 of the HCV genome. Fragments were purified by agarose gel electrophoresis and cloned into the plasmid pRS2. Multiple independent clones were sequenced by the standard dideoxy-mediated chain termination methods using the Sequenase version 2.0 DNA Sequencing Kit (USB).

Cell-free translation

Cell-free translation reactions were performed in reticulocyte extracts (Promega) using conditions recommended by the manufacture. Usually 0.1-1 µg of the same in vitro synthesized RNAs used in transfection experiments were used in 25 µl translation reactions. After 45 min of incubation at 30 °C, 2 µl were dissolved in 10 µl of sample buffer, and those samples were analyzed by sodium dodecyl sulfate PAGE. Labeled proteins were visualized by autoradiography of the dried gel. The efficiency of translation was measured using phosphorimager analysis (Molecular Dynamics) by comparing the radioactivity in the band corresponding to the N^{pro} protein. In preliminary experiments, an eightfold increase in incorporation was observed for translation of 4 µg versus 0.4 µg BVDV transcript RNA. Quantitative data were obtained from reactions using subsaturating (0.4 µg) amounts of BVDV or BVDV chimera transcript RNAs.

Analysis of virus specific RNAs

The protocols used for radioactive labeling of virus-specific RNAs are described in the appropriate figure legends. RNAs were isolated from the cells by using TRIzol reagent as recommended by the manufacturer (Gibco-BRL). After denaturation with glyoxal in dimethylsulfoxide, cellular RNAs were analyzed by electrophoresis in a 1% agarose gel containing a 10 mM phosphate buffer. Pieces of the dried gel containing the appropriate RNA bands were excised, and their radioactivity measured by liquid scintillation counting.

Results

10 Features of the BVDV, HCV, and EMCV 5' NTRs important for chimera design

Schematic representations of the proposed secondary structures of the 5' NTRs of HCV, BVDV, and EMCV are shown, and the location of each IRES is indicated in Figure 1. EMCV is a member of the cardiovirus genus within the family *Picornaviridae*. While not a member of the *Flaviviridae*, EMCV is similar to HCV and BVDV in that it is a positive-strand RNA virus shown to contain an IRES within its 5' NTR (Jang et al., *J. virol* 62:2636-2643, 1988). Based on their proposed secondary structures, the HCV IRES and the BVDV IRES have been classified as type 3 IRESs, while the EMCV IRES is classified as a type 2 IRES (Lemon & Honda, *Siemin. Virol.* 8:274-288, 1997). However, these three IRESs as well as IRESs from other members of the *Flaviviridae* and the *Picornaviridae* have been proposed to contain a common structural core (Le et al., *Virus Genes* 12:135-147, 1996).

The model for the secondary structure of the 341-nt HCV 5' NTR has been refined by enzymatic and chemical analysis of synthetic transcripts (Brown et al., *Nucl. Acids. Res.* 20:5041-5045, 1992; Wang et al., *J. Virol* 68:7301-7307, 1994; Honda et al., *RNA* 2:955-968, 1996; Lima et al., 1997). This element contains four discrete hairpins (referred to here as H1, H2, H3 and H4) and a pseudoknot at the base of hairpin H3 (Wang et al., 1995). The secondary structure of the 385-nt BVDV 5' NTR has not been as extensively studied, but is proposed to be similar to that of HCV (Brown et al., 1992) with four discrete hairpins (referred to here as B1', B1, B2, and B3) and a pseudoknot at the base of B3 (Rijnbrand et al., 1997). The secondary structure of the longer (>700 nt) EMCV 5' NTR consists of a series of hairpins A-M (Duke et al., 1992; Hoffman & Palmenberg, 1996). Recently, a revised model of the EMCV 5' NTR suggests moderately different secondary structures for the C and G subregions, and significantly different secondary structures for the I-M subregion (Palmenberg & Sgro, 1997).

For HCV, H1 is nonessential for IRES function (Reynolds et al., 1995; Rijnbrand et al., 1995; Honda et al., 1996b; Reynolds et al., 1996; Kamoshita et al., 1997) and its deletion

has actually increased translation efficiency in some analyses (Rijnbrand et al., 1995; Honda et al., 1996b). Most studies have found that hairpin H2 and H3 and the pseudoknot are essential for IRES function (Wang et al., 1993; Rijnbrand et al., 1995; Honda et al., 1996b). However, two studies indicate that H2 may not be essential (Tsukiyama-Kohara et al., 1992; Urabe et al., 1997). The 3' boundary of the HCV IRES is more controversial. The IRES clearly extends to the AUG initiation codon. However, some studies indicate that sequences affecting the efficiency of translation initiation extend into the ORF (Reynolds et al., 1995; Honda et al., 1996a; Honda et al., 1996b; Lu & Wimmer, 1996). By analogy to the HCV IRES and the related pestivirus CSFV IRES, the BVDV IRES probably requires hairpins B2 and B3 and the pseudoknot for function, with B1ⁱ and B1 probably not required for IRES activity (Poole et al., 1995; Rijnbrand et al., 1997). For EMCV, hairpins H-L have been shown to be required for IRES function in mono- or dicistronic constructs (Jang & Wimmer, 1990; Duke et al., 1992). The remaining portion of the EMCV 5' NTR is thought to be required for RNA replication or unknown steps in viral replication that are important for pathogenesis (Duke et al., 1990; Martin & Palménberg, 1996).

Replacement of the BVDV 5' NTR with the HCV 5' NTR results in a large decrease in specific infectivity

Since the BVDV 5' NTR and the HCV 5' NTR are proposed to have similar RNA secondary structure and functional organization, an experiment was performed to test whether the BVDV 5' NTR could be replaced by the HCV 5' NTR. p5' HCV has an exact replacement of the BVDV 5' NTR with that of HCV (Fig. 2A) while the coding sequence and 3' NTR of p5'HCV are identical to pBVDV. Positioning of the HCV 5' NTR in such a manner was necessary since translation initiation from the HCV IRES begins at or near the AUG start codon (Honda et al., 1996a; Reynolds et al., 1995; Reynolds et al., 1996; Rijnbrand et al., 1996). The specific infectivity of 5'HCV RNA synthesized in vitro was compared to that of BVDV RNA by transfection of MDBK (bovine kidney) cells (Fig. 2A). The specific infectivity of BVDV RNA was approximately 4×10^6 plaque forming units (PFU)/ μ g RNA. In contrast, the specific infectivity of 5' HCV RNA was near the limit of detection (30-50 PFU/ μ g RNA) and considerable plaque heterogeneity was apparent. These results suggested that the HCV 5' NTR replacement chimera might be incapable of efficient replication and plaque formation and that the plaque forming virus observed had arisen by secondary mutation(s). Sequence analysis of plaque-purified 5' HCV viruses presented below confirmed that the replicating pool of virus contained such pseudorevertants.

Next, the *in vitro* translation efficiency of these two RNAs in rabbit reticulocyte extracts was analyzed to test whether the defect in specific infectivity of 5' HCV RNA could be attributed to lower translation efficiency. Although the specific infectivity of 5' HCV RNA was reduced ~5 logs compared to BVDV RNA, its translation efficiency was only slightly reduced, ~twofold (Fig. 3, lane 1 vs. lane 2). The apparent size of the N-terminal cleavage product, N^{pro}, was identical for both RNAs, suggesting that translation initiated with the correct AUG. These data are consistent with the hypothesis that the BVDV 5' NTR contains signals that are required for a step in replication other than translation which are not present in the 5' HCV chimera.

Given the low specific infectivity of 5' HCV RNA, an experiment was performed to test the effect of placing the BVDV 5' NTR sequence upstream of the HCV 5' NTR, resulting in tandem BVDV and HCV 5' NTRs (called BVDV + HCV). This arrangement actually decreased translation efficiency (Fig. 3, lane 14 vs. lane 1) yet restored infectivity (Fig. 2A). The plaques produced by BVDV + HCV were also heterogeneous in size, indicating that this virus was unstable. Upon passage, RT-PCR analysis indicated that pseudorevertants had indeed arisen in which portions of the BVDV and/or HCV 5' NTRs had been deleted (data not shown). These data show that sequences in the BVDV 5' NTR required for virus replication can function when placed upstream of a functional HCV IRES driving translation of the BVDV polyprotein.

Hairpins B1' and B1 in conjunction with the HCV IRES are sufficient for stable and efficient BVDV replication

The sequences within the BVDV 5' NTR that restored replication in the context of the HCV 5' NTR were mapped using three deletion variants. The deletion BVDV + HCVdelB3 removed a large portion of hairpin B3; the deletion within BVDV + HCVdelB2B3 removed hairpins B2 and B3, and the deletion within BVDV + HCVdelB1B2B3 removed hairpins B1, B2 and B3. The specific infectivities of RNAs from these deletion mutants were near that of BVDV RNA (Fig. 2). Upon passage of these viruses, RT-PCR analyses and sequencing indicated that BVDV + HCV delB3 and BVDV + HCVdelB2B3 were stably propagated and produced homogeneous plaques slightly smaller than those of wild-type BVDV (data not shown). In contrast, BVDV + HCVdelB1B2B3 produced smaller heterogeneous plaques. Reverse transcription-polymerase chain reaction (RT-PCR) analysis and sequencing indicated that BVDV + HCVdelB1B2B3 underwent a reversion event described in more detail below. The translation efficiencies of these three RNAs (Fig. 3, lanes 9, 10, and 12) were similar to BVDV + HCV RNA (Fig. 3, lane 14), indicating that the deleted portions (hairpins B1, B2,

and B3) are not required for translation in the BVDV + HCV chimera. These results show that B1' and B1 are the minimal elements sufficient for stable replication in conjunction with the HCV 5' NTR.

Having shown that B1' and B1 are sufficient for replication in conjunction with the HCV 5' NTR, we next conducted a deletion analysis to determine the sequences within the HCV 5' NTR of BVDV + HCV delB2B3 required for replication. A large portion of H1 was deleted in BVDV + HCV delB2B3H1, while both H1 and H2 were deleted in BVDV + HCV delB2B3H1H2. Of these two RNAs, only BVDV + HCV delB2B3H1 was as infectious as parental BVDV RNA (Fig. 2B). However, the BVDV + HCV delB2B3H1 virus produced smaller plaques than BVDV + HCV delB2B3, indicating that hairpin H1 may augment replication of the chimera. In contrast, BVDV + HCV delB2B3H1H2 RNA was not infectious (Fig. 2B) and was translated poorly (Fig. 3, lane 11). Diminished HCV IRES activity might be due to deletion of hairpin H2 or juxtaposition of BVDV hairpins B1' and B1 with H3. A third derivative of BVDV + HCV delB2B3, with a *Sma* I-*Sma* I deletion abrogating HCV IRES function by removing H3, was also not infectious (data not shown). Thus, a 5' NTR consisting of B1' and B1 and a functional HCV IRES is sufficient for stable BVDV replication in MDBK cells. Similar results were obtained in BT cells, another BVDV-permissive continuous bovine cell line (data not shown).

20 Replacement of the BVDV 5' NTR with the EMCV 5' NTR

The following experiment was performed to determine whether the BVDV 5' NTR could be replaced by the 5' NTR of a more phylogenetically distant virus, EMCV. A derivative of BVDV was created, called 5' EMCV, that contains an exact replacement of the BVDV 5' NTR with the EMCV 5' NTR plus an additional guanosine residue at the 5' terminus for more efficient transcription initiation of T7 polymerase (Fig. 4A). The specific infectivity of 5' EMCV RNA was more than three orders of magnitude lower than BVDV RNA, indicating that it was defective for replication, although its specific infectivity was higher than that of 5' HCV RNA (compare Figs. 4A and 2A). Similar to 5' HCV, 5' EMCV produced heterogeneous plaques, and sequence analysis indicated that pseudorevertants had arisen. The lower specific infectivity of 5' EMCV RNA was not likely because of a defect in translation, since the translation efficiency of 5' EMCV RNA was about threefold higher in vitro than that of BVDV RNA (Fig. 3, lane 20 vs. lane 19).

Similar to BVDV + HCV, it was also determined whether the BVDV 5' NTR at the 5' end of the 5' EMCV RNA would increase its specific infectivity. BVDV + EMCVdelA (Fig. 4A) contained the entire BVDV 5' NTR in tandem with the EMCV 5' NTR lacking a portion

of hairpin A. BVDV + EMCVdelA RNA had a specific infectivity near that of BDVD RNA (compare Figs. 4A and 2A) despite having a lower translation efficiency than 5' EMCV (Fig. 3, lane 21 vs. lane 20). Similar to the results with BVDV + HCV, this implicates the added BVDV 5' NTR sequence for a step in viral replication other than translation. Two derivatives of BVDV + EMCVdelA that contain deletions of portions of the BDVD 5' NTR but maintain the sequence of B1' and B1, BDVD + EMCVdelB3A and BVDV + EMCVdelB2B3A (Fig. 4A), also were infectious. These derivatives had translation efficiencies near that of the parental BVDV + EMCVdelA (Fig. 3, compare lanes 15 and 16 with lane 21). This demonstrated that hairpins B1' and B1 were sufficient for replication in conjunction with a large portion of the EMCV 5' NTR. Derivatives of BVDV + EMCVdelB3A or BVDV + EMCVdelB2B3A that contain further deletions of EMCV (BVDV _ EMCVdelB3ABC and BVDV + EMCVdelB2B3ABC in particular) were translated efficiently (Fig. 3, lanes 17 and 18) and were infectious (Fig. 4B). This indicates that the chimeras did not require putative EMCV RNA replication signals (Martin & Palmenberg, 1996). However, derivatives with deletions extending into the canonical EMCV IRES were not infectious. For example, BVDV + EMCVdelB3A-H and BVDV + EMCVdelB2B3A-H, in which a portion of hairpin H is deleted, were not infectious (Fig. 4B) and were inefficiently translated in vitro (Fig. 3, lanes 22 and 23). It should be noted that all of the BVDV + EMCV chimeras produced plaques of heterogeneous size, indicating some instability.

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Relatively simple 5' NTR mutations are observed in adapted pseudorevertants

As mentioned previously, BVDV + HCVdelB1B2B3 did not replicate stably as indicated by the heterogeneity in the size of plaques produced by this virus. Upon passage and selection of medium plaque-producing variants, 5' RACE analysis and sequencing indicated that nt 1-26 had been deleted in the pseudorevertants, removing a large portion of B1' which was apparently deleterious in the absence of B1. This deletion results in the 5' terminal sequence 5'GUAUCG which is identical to the first six bases of BVDV genome RNA (Fig. 5) and is repeated at positions 27-32.

Analysis of the passaged 5' EMCV virus indicated that the replicating progeny had also undergone a simple deletion of sequence at the 5' end to generate more efficiently replicating variants (Fig. 5). After electroporation, the 5' EMCV virus pool was passaged 5 times at a multiplicity of infection of 0.1-1 PFU/cell on MDBK or BT cells, and the 5' termini of three randomly picked plaques were sequenced. For all three plaques selected, nt 2-209 had been deleted, again creating a genome RNA with the 5' terminal tetranucleotide sequence 5'-GUAU.

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Analysis of the 5' HCV progeny indicated that more complicated variants had arisen. Most small plaque-producing variants were unstable and quickly reverted to medium plaque-producing variants. However, one small plaque-producing variant and two stable medium plaque-producing variants were isolated. 5' terminal sequences of the variants were amplified by rapid amplification of cDNA ends (RACE) and cloned into a plasmid vector, and sequences for several independent colonies were determined. The sequence of three clones of the small plaque-producing virus (5'HCV.R1) contained a deletion of HCV sequence from nt 1-34 and an addition of the dinucleotides 5'-AU in two clones and 5'-GU in the third clone. This creates a 5' terminus of 5'-(G/A) UAA (Fig. 5B), reminiscent of the first three bases of the BVDV genome RNA (5'-GUA). Both medium plaque variants appeared to have arisen by RNA recombination with non-viral sequences (Fig. 5). One medium plaque variant (5' HCV.R2) had deleted the first 21 bases of the HCV sequence and contained instead a heterologous sequence of 22 bases. BLAST searches revealed a perfect match between this sequence and a sequence in a human retina cDNA of unknown function (Tsp509I). The second medium plaque variant (5' HCV.R3) had also undergone a possible recombination event leading to the addition of 12 nt to the 5' end of the HCV sequence. Given its short length, multiple matches were found in the database with this sequence. As for the small plaque variant, sequencing of multiple clones revealed heterogeneity at the extreme 5' end, with either G or A identified as the 5' base. Remarkably, for both medium plaque variants, the fused heterologous sequence began with the tetranucleotide sequence 5'-(G/A) UAU (Fig. 5B). For all three variants, sequencing of the entire 5' NTR and a portion of the N^{pro} coding region revealed only these changes at the 5' termini.

5' NTR sequence changes are sufficient for the pseudorevertant phenotypes

To assess the importance of these alterations at the 5' terminus of the 5' HCV pseudorevertants, derivatives of 5' HCV were created with the changes determined by 5' RACE (Fig. 6A) and analyzed the specific infectivities of these RNAs (Fig. 6B). Corresponding to the small plaque variant, a derivative called 5' HCV.R1 orig was engineered which contained a 5' NTR consisting of the dinucleotide 5' -GU at the 5' terminus of HCV nt 35-341. This results in a 5' terminus consisting of 5'-GUAA. 5'HCV.R1 orig RNA had a specific infectivity at least four orders of magnitude higher than 5' HCV RNA (Figs. 6B and 2A). This demonstrates that this 5' NTR structure is sufficient for phenotypic reversion to high specific infectivity. However, small plaques and considerable heterogeneity were observed for 5'HCV.R1 orig suggesting that additional mutations may be present in the original small plaque variant.

The engineered derivative 5'HCV.R2orig had a 5' NTR consisting of 22 nt of Tsp509I-homologous sequence followed by HCV nt 22-341. Another construct, called 5'HCV.R3orig was made, which has the 12 nt of the other heterologous sequence fused to the intact HCV 5' NTR. Specific infectivities for both these derivatives were essentially the same as observed for wild type BVDV RNA ($2-4 \times 10^6$ PFU/ μ g; Fig. 6B). Transfection with these transcripts produced medium plaques, as observed for the original variants, and this phenotype was stable upon passaging. These results show that the altered 5'NTR sequences were responsible for the pseudorevertant phenotypes rather than changes elsewhere in their genomes.

Addition of the tetranucleotide sequence 5'-GUAU to the HCV 5' NTR allows efficient BVDV replication

For all three 5' HCV variants studied, as well as the BVDV + HCV delB1B2B3 and 5'EMCV pseudorevertants, 5' NTR alterations seemed to involve creation of a three- or four-base "consensus" sequence identical to the 5' terminus of BVDV genome RNA. To test the importance of this sequence, as opposed to fused heterologous sequences, we created a set of variants with the BVDV 5' tetranucleotide sequence linked to the HCV 5' NTR or the deletion/recombinant break points identified during sequence analysis of the 5' HCV pseudorevertants (Fig. 6A). 5' HCV.R1cons had the tetranucleotide sequence 5'-GUAU fused to HCV nt 35-341. 5'HCV.R2cons had the 5'-GUAU tetranucleotide sequence fused to HCV nt 22-341. 5'HCV.R3cons contained the tetranucleotide sequence 5'-Guau fused to the intact 5' terminus of the HCV NTR. RNAs from all three of these derivatives had specific infectivities more than five orders of magnitude higher than 5'HCV and comparable to parental BVDV (Fig. 6B).

There were, however, significant differences between the phenotypes of some of these derivatives versus the reconstructed pseudorevertants. As mentioned above, 5'HCV.R1orig yielded tiny and small plaques and produced low virus yields even after 48 h. In contrast, the addition of four bases rather than two bases (5'-GUAU vs. 5'-GU) yielded virus with near wild-type plaque morphology (Fig. 6B) and growth Rates (Fig. 7). In the case of the smaller deletion, 5'HCV.R2orig and 5'HCV.R2cons were indistinguishable, suggesting that, other than the 5' four bases, the fused heterologous sequences were dispensable. This was not the case, however, for the chimera containing the 5'-GUAU tetranucleotide sequence

fused to the intact HCV 5' NTR. 5'HCV.R3cons produced small plaques (Fig. 6B) and grew more slowly than 5'HCV.R3orig (Fig. 7) suggesting that the sequence/structure of the sequences downstream of the 5' four bases can affect replication efficiency.

5 The tetranucleotide sequence 5'-GUAU is important for efficient BVDV RNA accumulation

Next, the effects of the different 5' termini on virus-specific RNA accumulation directly after transfection were analyzed. This allowed a direct comparison between 5'HCV and the reconstructed pseudorevertants as well as selected BVDV + HCV deletion constructs. 10 MDBK cells were transfected with in vitro synthesized RNAs and labeled for 10 h beginning at 5 h post-transfection with ³H-UTP in the presence of actinomycin D (Fig. 8). RNA replication of the 5' HCV chimera was severely impaired to a level below detection (Fig. 8, lane 2). In contrast, every 5' NTR alteration of 5' HCV that increased RNA specific infectivity and allowed efficient virus growth led to readily detectable viral RNA 15 accumulation. Addition of B1' and B1 to the 5' terminus of the HCV 5' NTR restored RNA replication to a level ~50% of that observed for BVDV (BVDV + HCVdelB2B3; Fig. 8, lane 3 vs. lane 1). BVDV + HCVdelB2B3H1 displayed reduced RNA synthesis compared to BVDV + HCVdelB2B3 (Fig. 8, lane 4 vs. lane 3) perhaps explaining its small plaque phenotype and suggesting a possible positive role for H1 in replication of this chimera. 20 5'HCV.R1orig, which had exhibited plaque heterogeneity and slow growth, accumulated less RNA when compared to 5'HCV.R1cons (Fig. 8, lane 5 vs. lane 6). 5'HCV.R2orig and 5'HCV.R2cons showed similar RNA accumulation (Fig. 8, lane 9 vs. lane 10) consistent with their medium plaque phenotypes; and 5'HCV.R3cons exhibited reduced RNA synthesis compared to 5'HCV.R3orig (Fig. 8, lane 8 vs. lane 7), consistent with their small-versus 25 medium-plaque phenotypes.

Although these RNA phenotypes are complex, the most striking result is that addition of the B1' B1 hairpins, addition of heterologous 5' sequences terminating with 5'-GUAU or simply fusion of this tetranucleotide sequence with the HCV 5' NTR or short 5' truncations of the HCV 5' NTR all dramatically upregulated RNA accumulation. This occurred without 30 increasing translation efficiency, at least as measured in a cell-free assay (Fig. 3, compare lanes 3-8 to lane 1), suggesting that these sequences function at the level of RNA replication or stability.

Discussion

The work presented here helps to define the requirements for a functional BVDV 5'NTR. The BVDV-specific 5' NTR sequences required for efficient replication in cell culture are minimal and consist of the 5' terminal sequence, 5'-GUAU. The sequence 5'-AUAU, detected for some pseudorevertants, may also be functional but this was not tested for technical reasons. This simple 5'-terminal tetranucleotide sequence, which is conserved among pestiviruses (Ruggli et al., 1996; Becher et al., 1998), was shown to function in the context of functional IRES elements derived from the hepatitis C virus HCV or the picornavirus EMCV. As discussed below, this may indicate that the 5' signals required for BVDV RNA replication are rather simple or that elements in these heterologous IRESs can functionally replace deleted BVDV sequences.

Sequences at the extreme 5' end of BVDV genome RNA could modulate the efficiency of RNA accumulation by affecting RNA stability, translation, promoter efficiency, or some combination of these processes. At this time, we can not distinguish among these possibilities but favor an effect on RNA replication. The complement of the BVDV 5' sequence at the 3' end of the negative-strand RNA presumably functions in the initiation of positive-strand RNA synthesis. Thus, AUAC-3' at the 3'terminus of minus-strand RNA may be important for positive-strand RNA synthesis. Interestingly, for some positive-strand RNA viruses such as rubella virus (Pugachev & Frey, 1998), flock house virus (Ball, 1994) and turnip crinkle virus (Guan et al., 1997), only minimal *cis*-acting sequences at the 3' termini of negative-strand RNAs are required for positive-strand RNA synthesis. In contrast to the 5' NTR replacements, we were unable to generate replication-competent BVDV-HCV replacing that of BVDV (data not shown). This may indicate that the signals within the pestivirus 3' NTR required for initiation of negative-strand RNA synthesis are more complex and virus specific. Once the replication complex has assembled at the 3' NTR and transversed the RNA during negative-strand synthesis, the requirements of the 5' NTR for initiation of positive-strand synthesis may be minimal.

Although the RNA replication signals within the 5' NTR appear to be rather simple, it is possible that the signals important for RNA replication actually extend into the IRES and are more complicated. For instance, the 5'HCV pseudorevertants were more stable and grew to higher titers than the 5'EMCV counterparts, despite the fact that the 5'EMCV RNAs were translated more efficiently *in vitro*. This may indicate that the BVDV and HCV IRESs contain signals important for RNA synthesis that are absent in the EMCV IRES.

It is perhaps not surprising that 5' HCV appeared to recombine with cellular mRNAs to acquire a 5' terminus with the 5' -(G/A) UAU consensus, given that non-cytopathic strains

of BVDV can recombine with BVDV RNA or cellular mRNAs to generate cytopathic strains of BVDV (Meyers & Thiel, 1996). Presumably, this recombination event involves template switching during negative-strand RNA synthesis, as observed for polio-virus (Kirkegaard & Baltimore, 1986). In contrast to 5' HCV, simple deletions of 5' terminal viral sequences could
5 account for the BVDV + HCVdelB1B2B3 and 5'EMCV pseudorevertants since the tetranucleotide sequence is present in these 5' NTRs upstream of functional IRES elements. Such deletions could occur by partial degradation of positive-strand template prior to negative-strand synthesis, by premature termination during negative-strand RNA synthesis, or by degradation of 3' terminal negative-strand sequence after synthesis. It is proposed that
10 5'HCV was forced to recombine with cellular sequences because HCV does not have an 5'-(G/A) UAU sequence upstream of its IRES. The first occurrence of an (G/A)UAUA tetranucleotide sequence is at nt 94-97 within hairpin H2, and a 5' deletion extending into this sequence would presumably inactivate or severely impair HCV IRES activity. It is interesting that BVDV + HCVdelB1B2B3 and 5'EMCV pseudorevertants were generated at much higher
15 frequency than 5'HCV pseudorevertants. This may indicate that recombination between BVDV and cellular RNAs is a rare event compared to the processes which lead to deletion of terminal viral sequences.

Poliovirus chimeras dependent upon a functional HCV IRES have been reported (Lu & Wimmer, 1996). Interestingly, viable poliovirus chimeras were produced only when HCV
20 sequences included both the IRES and the N-terminal portion of the HCV ORF. Nucleotide sequences or structures in the downstream ORF can modulate HCV IRES translational efficiency (see Reynolds et al., 1995; Honda et al., 1996a) but it was also suggested that the N-terminal portion of the HCV core polypeptide might be involved. In the case of our 5' HCV pseudorevertants, there is no requirement for HCV C protein sequences. Although the
25 translation efficiency of the HCV IRES in the presence of additional HCV sequences 3' to the AUG start was not directly assessed, the HCV chimeras and pseudorevertants were translationally active and infectious in the absence of any portion of the HCV ORF. This indicates that either the HCV IRES does not extend into the HCV ORF or that the BVDV ORF contains analogous sequence which functions in our 5'HCV chimeras. There is some
30 limited identity between HCV and BVDV within this region. For example, HCV nt 359-394 and BVDV nt 405-440 are identical at 21 of 36 positions, although identity within this sequence may be attributed to a high adenosine content. It is interesting to note that the luciferase (LUC) and chloramphenicol acetyl transferase (CAT) reporter genes previously used to detect HCV IRES activity (Tsukiyama-Kohara et al., 1992; Wang et al., 1993) also
35 have adenosine- or purine-rich regions in relatively the same position as the HCV ORF and

BVDV ORF. It this region is indeed important for IRES activity, this may explain why some have observed that the HCV IRES does not require a portion of the HCV ORF for translation of CAT or LUC (Tsukiyama-Kohara et al., 1992; Wang et al., 1993). Point mutations and insertions within this region of HCV have been shown to reduce HCV IRES activity in vitro
5 (Honda et al., 1996a,b).

Despite the fact that B1' and B1 are conserved among different strains of BVDV and similar hairpins are present in border disease virus and CSFV (Deng & Brock, 1993; Becher et al., 1998), B1' and B1 were dispensable for BVDV replication, provided that the 5' tetranucleotide sequence 5'-(G/A)UAA remained. This may indicate a role for B1' and B1 in
10 viral replication in vivo that we do not observe in cell culture. It will be interesting to test the phenotype of chimeras that lack B1' and B1 in vivo to determine if they are attenuated and might serve as useful BVDV vaccines. In this vein, several studies with flaviviruses have demonstrated that alterations in 5' NTR or 3' NTR elements can lead to attenuation in vivo (Cahour et al., 1995; Men et al., 1996; Mandl et al., 1998). BVDV chimeras that utilize the
15 HCV or EMCV IRES may also prove to be attenuated simply due to the presence of the heterologous IRES. For poliovirus, it has been shown that differences in IRES efficiency in different host-cell environments can modulate host range and virulence (Shiroki et al., 1997).

BVDV-HCV chimeras that are dependent on a functional HCV IRES may have another practical application. It may be possible to use these chimeras to screen for anti-HCV
20 therapeutics that target the HCV IRES. Other researchers have shown antisense oligonucleotide-mediated inhibition of HCV gene expression in hepatocytes by targeting the oligonucleotides to the HCV IRES (Hanecak et al., 1996). It will be of interest to measure the efficacy of antisense oligonucleotides or ribozymes (Lieber et al., 1996) against replicating virus, and these chimeras are more useful than HCV for this purpose since they are able to
25 replicate efficiently in cell culture. BVDV is believed to be a reasonable model of HCV replication not only because of homology and conserved motifs within the 5' NTR but also because of similarities in overall genetic organization (Rice, 1996) and polyprotein processing strategy (Tautz et al., 1997; Xu et al., 1997).

In view of the above, it will be seen that the several advantages of the invention are
30 achieved and other advantageous results attained.

As various changes could be made in the above methods and compositions without departing from the scope of the invention, it is intended that all matter contained in the above description and shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

All references cited in this specification, including patents and patent applications, are hereby incorporated by reference. The discussion of references herein is intended merely to summarize the assertions made by their authors and no admission is made that any reference constitutes prior art. Applicants reserve the right to challenge the accuracy and pertinency of

5 the cited references.

What is Claimed is:

1. A polynucleotide comprising a chimeric viral RNA which comprises:
 - (a) a 5' nontranslated region (5' NTR);
 - (b) an open reading frame (ORF) region; and
 - 5 (c) a 3' nontranslated region (3' NTR);wherein at least one of said regions is chimeric and comprises a first nucleotide sequence from a pestivirus in operable linkage with a first nucleotide sequence from an hepatitis C virus (HCV), and wherein said chimeric viral RNA is replication-competent.
- 10 2. The polynucleotide of claim 1, wherein the chimeric region is the 5' NTR and the first pestivirus nucleotide sequence is from a bovine viral diarrhea virus (BVDV).
3. The polynucleotide of claim 2, wherein the BVDV nucleotide sequence is located at the 5' terminus of the chimeric 5' NTR and comprises 5' RUAU.
- 15 4. The polynucleotide of claim 3, wherein the first HCV nucleotide sequence in the chimeric 5' NTR comprises an internal ribosome entry site (IRES).
5. The polynucleotide of claim 4, wherein the ORF and the 3' NTR consist of
20 second and third BVDV sequences.
6. The polynucleotide of claim 5, wherein the 5' terminal sequence comprises 5' GUAU.
- 25 7. The polynucleotide of claim 4, wherein the ORF comprises a second HCV sequence encoding at least one structural protein operably linked to a second BVDV sequence.
8. The polynucleotide of claim 1, wherein the pestivirus is BVDV and the
30 chimeric region is the 3' NTR.
9. The polynucleotide of claim 8, wherein the first HCV sequence in the chimeric 3' NTR comprises the HCV 98 bp 3' terminal element (SEQ ID NO:X) operably linked to the first BVDV sequence.

10. A method for identifying compounds having antiviral activity against hepatitis C virus (HCV) comprising the steps of:

(a) providing a first cell containing a chimeric viral RNA which is replication-competent in the cell, the chimeric viral nucleic acid comprising a 5' nontranslated region (5' NTR), an open reading frame (ORF) region; and a 3' nontranslated region (3' NTR);
5 wherein at least one of said regions is chimeric and comprises a first nucleotide sequence from a pestivirus in operable linkage with a first nucleotide sequence from an hepatitis C virus (HCV);

(b) providing a second cell containing the pestivirus; and

10 (c) comparing the replication efficiency of the chimeric viral RNA acid in the presence and absence of a test compound to the replication efficiency of the pestivirus in the presence and absence of the test compound,
wherein a greater reduction in compound-induced replication efficiency of the chimeric viral RNA than the pestivirus indicates the compound has anti-HCV activity.

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11. The method of claim 10, wherein the chimeric region is the 5' NTR and the first pestivirus nucleotide sequence is from a bovine viral diarrhea virus (BVDV).

12. The method of claim 11, wherein the BVDV nucleotide sequence is located
20 at the 5' terminus of the chimeric 5' NTR and comprises 5' RUAAU.

13. The method of claim 12, wherein the first HCV nucleotide sequence in the chimeric 5' NTR comprises an internal ribosome entry site (IRES).

14. The method of claim 13, wherein the ORF and the 3' NTR comprise second
25 and third sequences from the BVDV.

15. The method of claim 10, wherein the pestivirus is BVDV and the chimeric region is the 3' NTR.

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16. A genetically-engineered virus comprising a chimeric RNA genome which comprises:

(a) a 5' nontranslated region (5' NTR);

(b) an open reading frame (ORF) region; and

35 (c) a 3' nontranslated region (3' NTR);

wherein at least one of said regions is chimeric and comprises a first nucleotide sequence from a pestivirus in operable linkage with a first nucleotide sequence from an hepatitis C virus (HCV), and wherein said chimeric RNA genome is replication-competent.

5 17. The genetically-engineered virus of claim 16, wherein the chimeric region is the 5' NTR and the first pestivirus nucleotide sequence is from a bovine viral diarrhea virus (BVDV).

10 18. The genetically-engineered virus of claim 16, wherein the BVDV nucleotide sequence is located at the 5' terminus of the chimeric 5' NTR and comprises 5' RUAAU and the first HCV nucleotide sequence in the chimeric 5' NTR comprises an internal ribosome entry site (IRES).

15 19. A vaccine against bovine viral diarrhea virus (BVDV) comprising an immunogenically-effective amount of a genetically-engineered virus comprising a chimeric RNA genome having:

- (a) a 5' nontranslated region (5' NTR);
- (b) an open reading frame (ORF) region; and
- (c) a 3' nontranslated region (3' NTR);

20 wherein at least one of said regions is chimeric and comprises a first nucleotide sequence from BVDV in operable linkage with a first nucleotide sequence from an hepatitis C virus (HCV), and wherein the genetically-engineered virus is attenuated as compared to BVDV.

25 20. The vaccine of claim 19, wherein the chimeric region is the 5' NTR and the BVDV nucleotide sequence is located at the 5' terminus of the chimeric 5' NTR and comprises 5' RUAAU and the first HCV nucleotide sequence in the chimeric 5' NTR comprises an internal ribosome entry site (IRES).

30 21. A polynucleotide comprising a chimeric viral RNA which comprises:

- (a) a 5' nontranslated region (5' NTR);
- (b) an open reading frame (ORF) region; and
- (c) a 3' nontranslated region (3' NTR);

wherein at least one of said regions is chimeric and comprises a first nucleotide sequence from a pestivirus in operable linkage with a heterologous nucleotide sequence and wherein
35 said chimeric viral RNA is replication-competent.

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BVDV

HCV

EMCVV

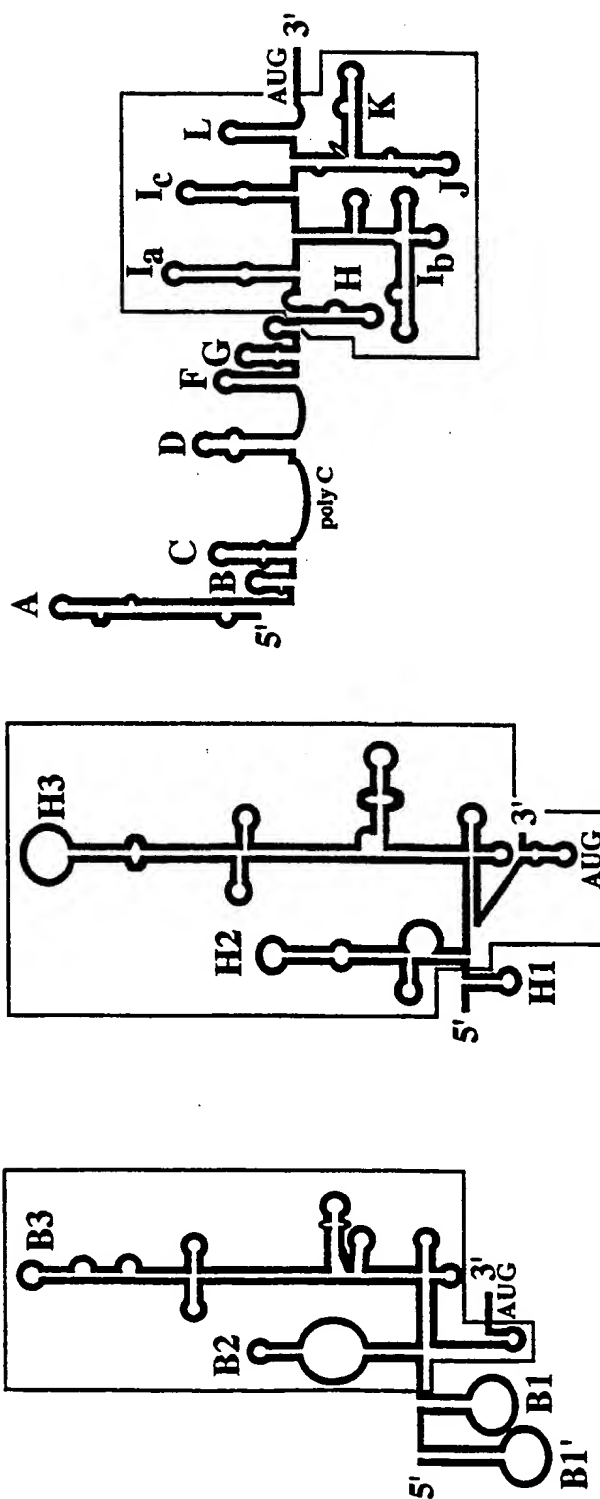


FIGURE 1

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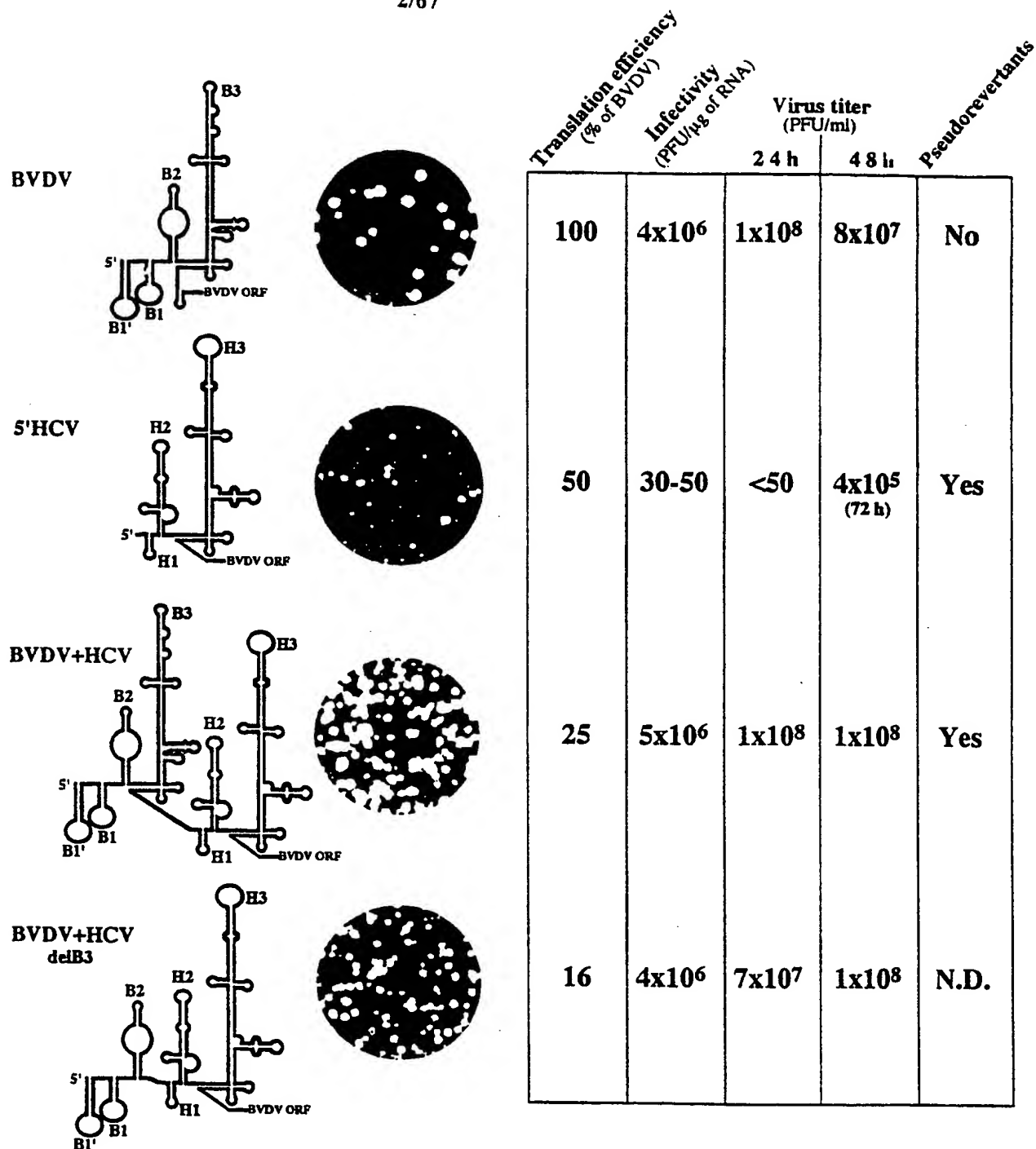


FIGURE 2A

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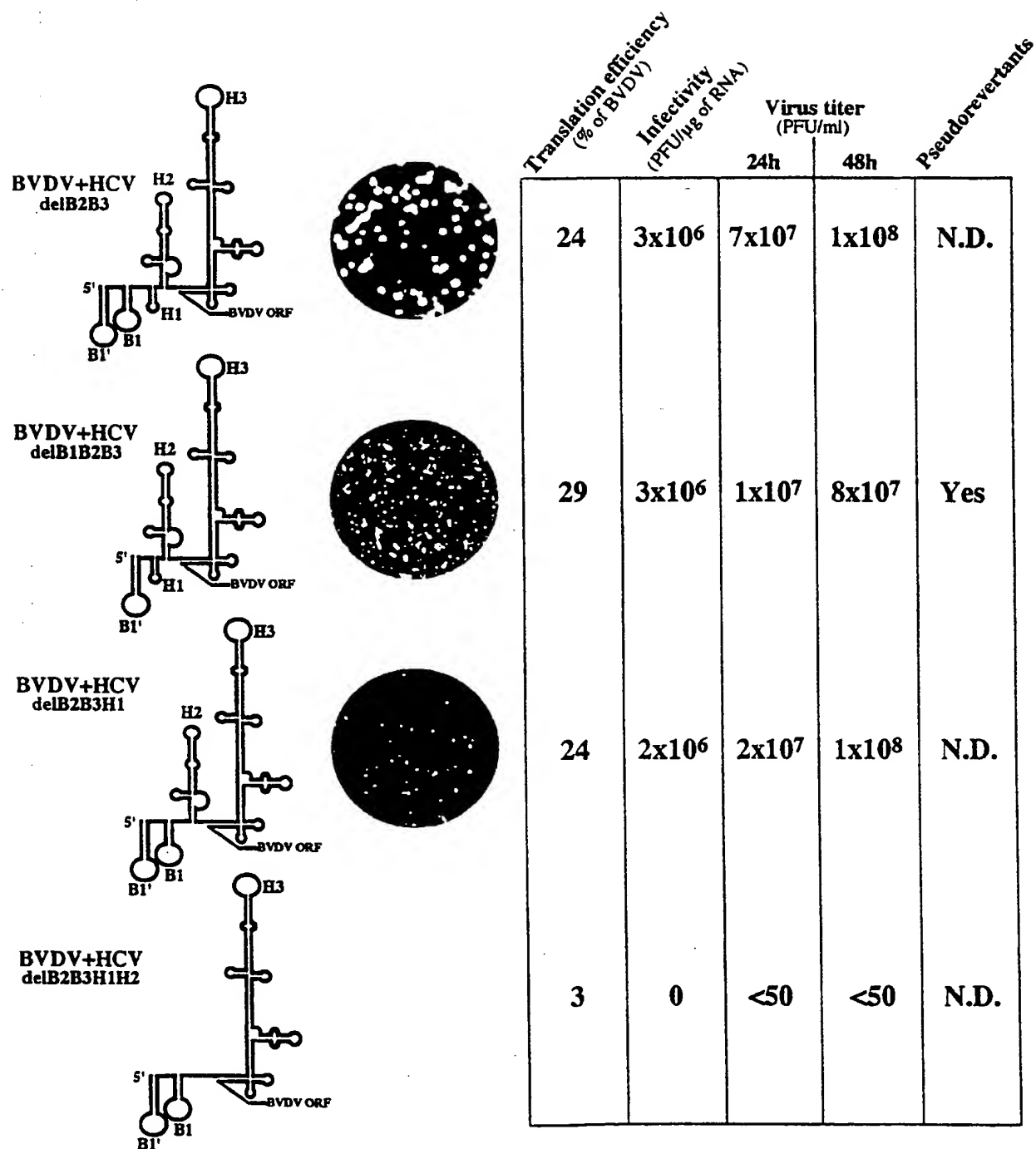


FIGURE 2B

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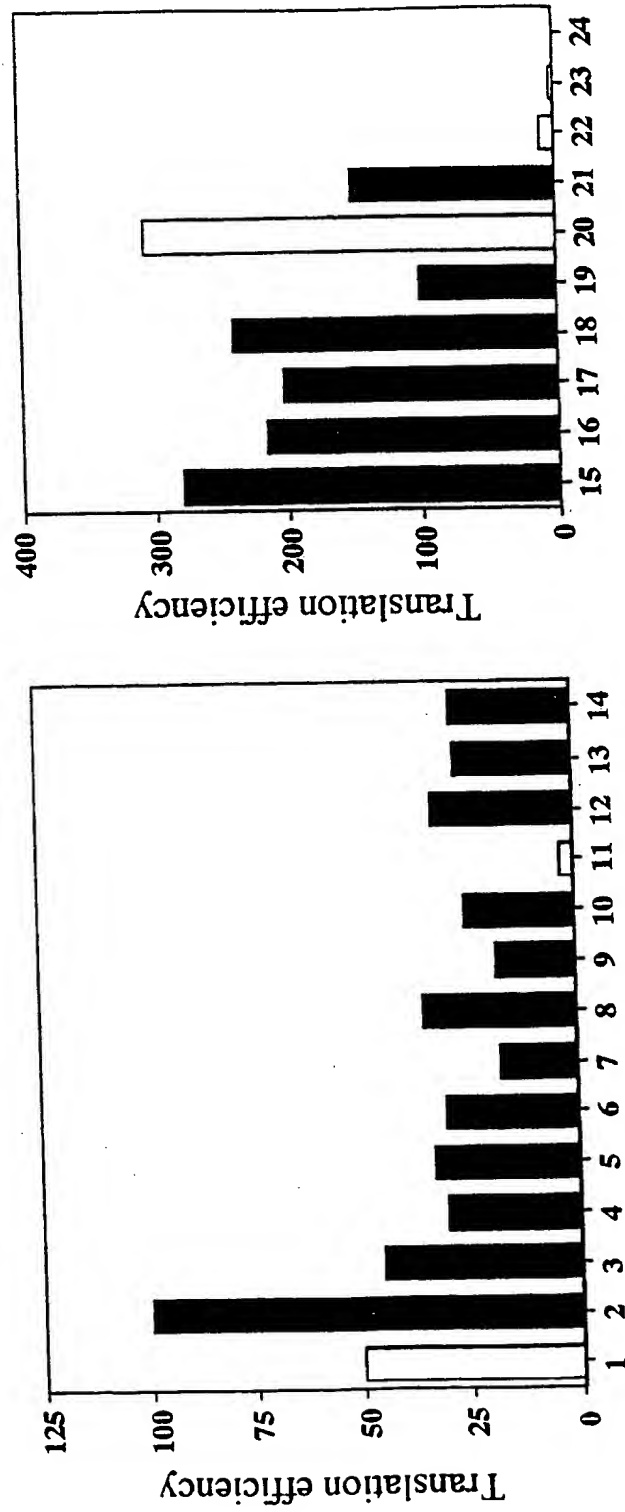


FIGURE 3

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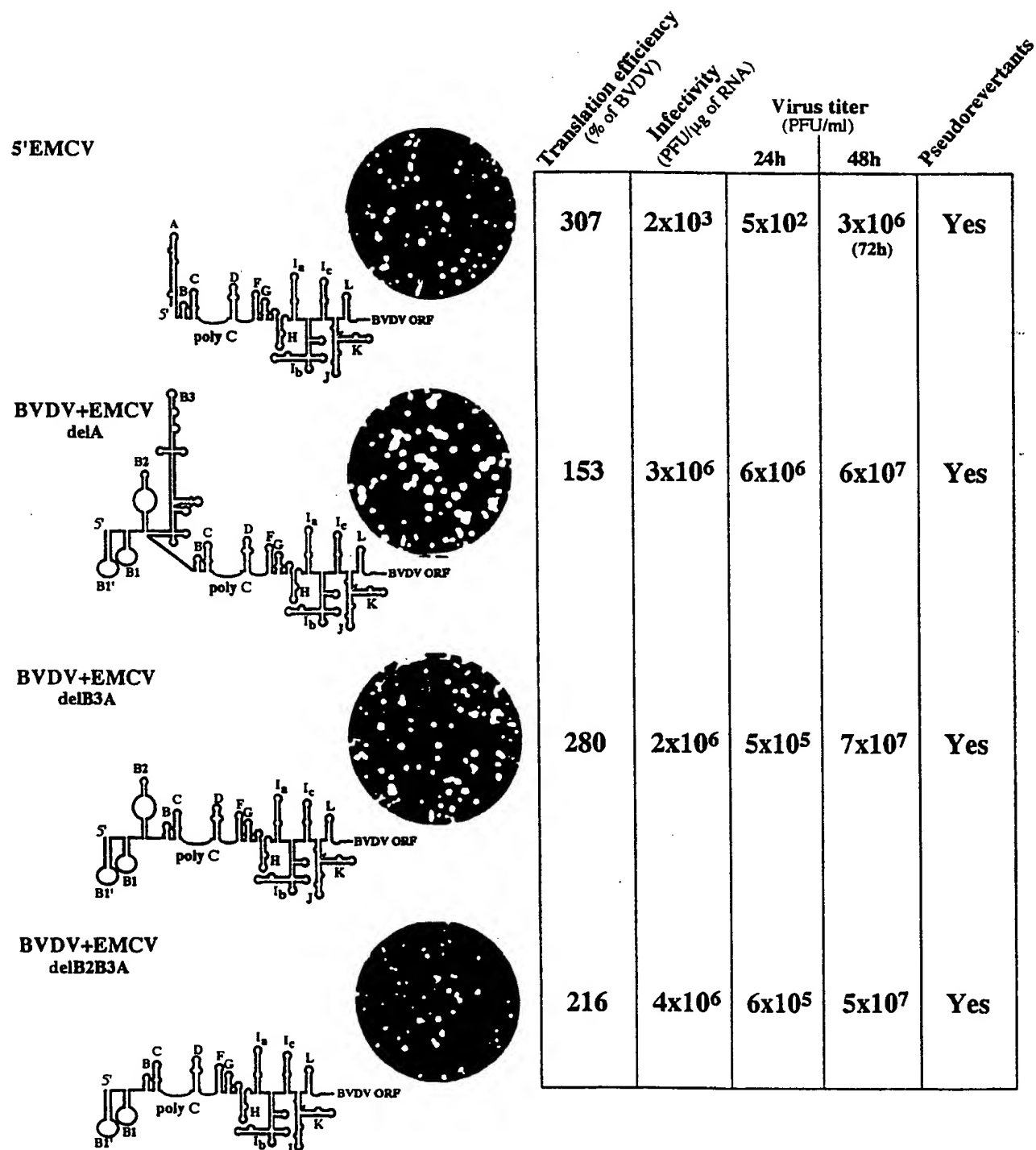


FIGURE 4A

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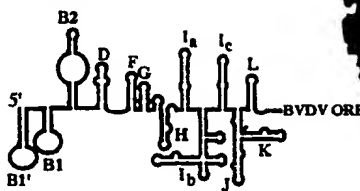
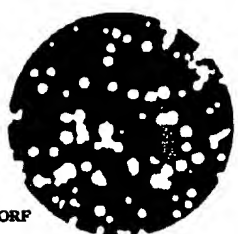
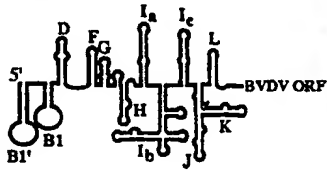
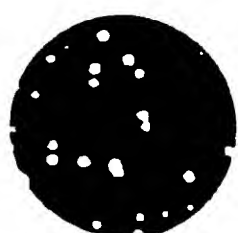
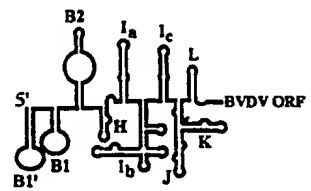
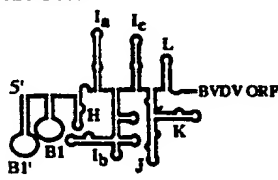
	Translation efficiency (% of BVDV)	Infectivity (PFU/ μ g of RNA)	Virus titer (PFU/ml)		Pseudorevertants
			24h	48h	
BVDV+EMCV delB3ABC  	202	3×10^6	8×10^6	6×10^7	Yes
BVDV+EMCV delB2B3ABC  	240	1×10^6	1×10^6	7×10^7	Yes
BVDV+EMCV delB3A-H 	12	0	<50	<50	No
BVDV+EMCV delB2B3A-H 	3	0	<50	<50	No

FIGURE 4B

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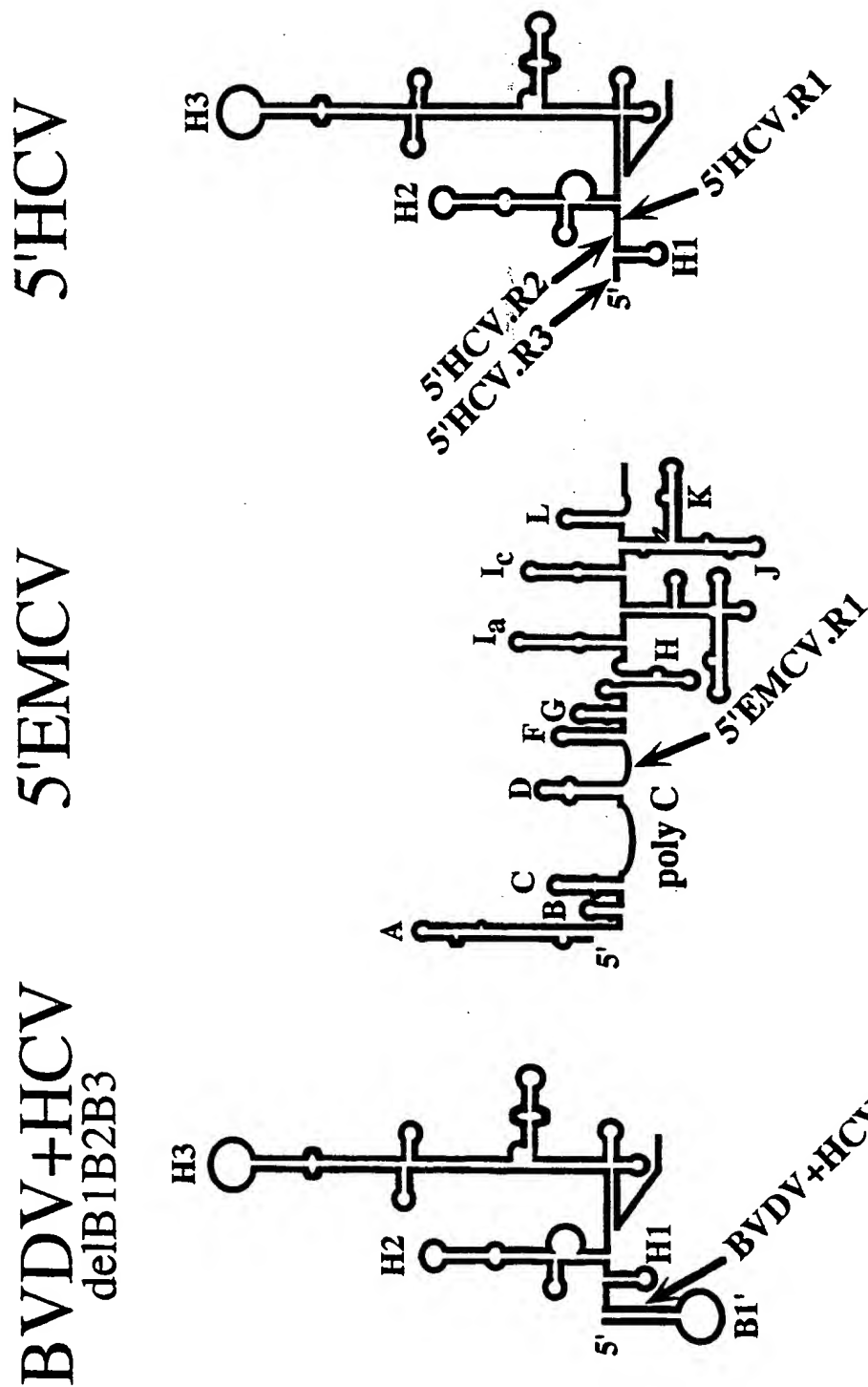


FIGURE 5A

/DV+HCVdelB1B2B3
 < B1' > < H1 >
IV+HCVdelB1B2B3 guauacgagaauuagaaaaggcacucguauacguaCAUGGCACGUGccagccccccugauggggc
IV+HCVdelB1B2B3.R1 guauacguaCAUGGCACGUGccagccccccugauggggc

ICV
 < H1 > < H2
 gccagccccccugaugggcgacacuccaccauccaagaaucaucuccccugugaggaaac
 (G/A) Uaaucacuccccugugaggaaac
ICV.R1
 (G/A) UAUCAGAGUGCGAUGCUGAacacuccaccauccaagaaucaucuccccugugaggaaac
 (G/A) UAUUGCAGUUUgccagccccccugaugggcgacacuccaccauccaagaaucaucuccccugugaggaaac
ICV.R2
ICV.R3

MCV
 1 201
 guugaaagccgggguggguuugcuauauguuuuuuccaccauauug
EMCV Guauguuuuuuuccaccauauug
EMCV.R1

FIGURE 5B

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A

5'HCV
 5'HCV.R1orig
 5'HCV.R1cons
 5'HCV.R2orig
 5'HCV.R2cons
 5'HCV.R3orig
 5'HCV.R3cons

```

gccagccccugauggggcgacacuccaccaccaugaaucaucuccccucugugaggaaacu
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      GUAUaucaucuccccucugugaggaaacu
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      GUAUacacuccaccaccaugaaucaucuccccucugugaggaaacu
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FIGURE 6A

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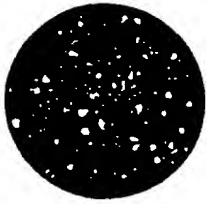
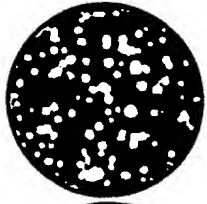
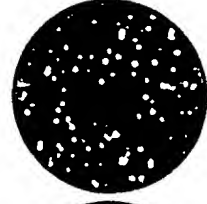
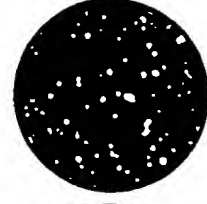


		Translation efficiency (% of BVDV)	Infectivity (PFU/ μ g of RNA)	Virus titer (PFU/ml)	
				24h	48h
BVDV		100	4×10^6	7×10^7	1×10^8
5'HCV.R1orig (5'-GUAA)		45	4×10^5	2×10^3	2×10^5
5'HCV.R1cons (5'-GUAAU)		29	3×10^6	4×10^7	5×10^7
5'HCV.R2orig (5'-GUAUCAGAAGUGCGAAUGCUGA)		17	2×10^6	7×10^6	5×10^7
5'HCV.R2cons (5'-GUAAU)		35	3×10^6	2×10^7	4×10^7
5'HCV.R3orig (5'-GUAUUGCAGUUU)		33	3×10^6	4×10^7	5×10^7
5'HCV.R3cons (5'-GUAAU)		30	3×10^6	1×10^7	6×10^7

FIGURE 6B

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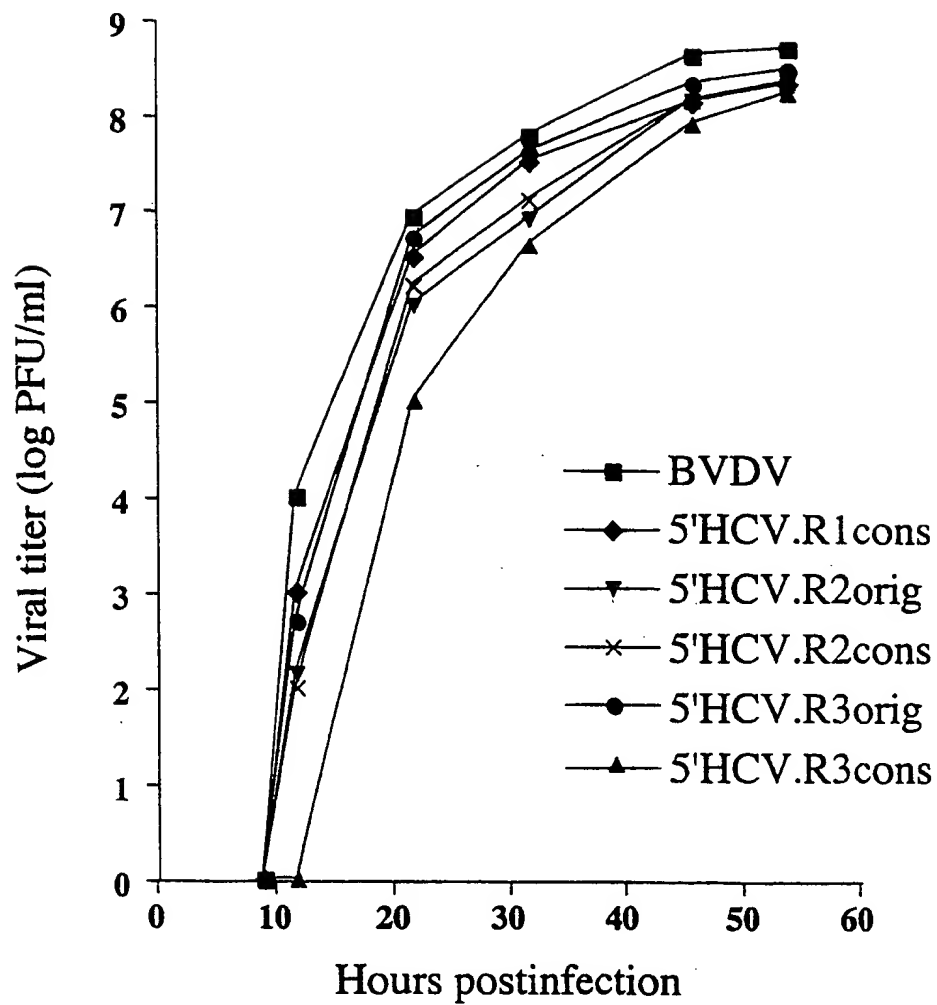


FIGURE 7

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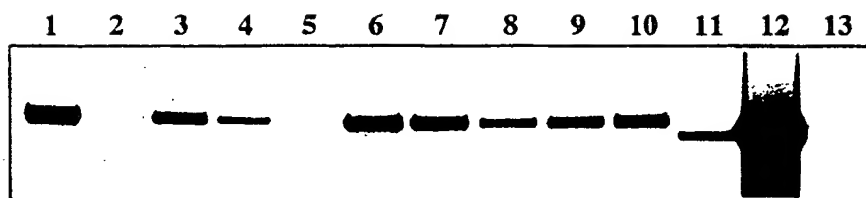
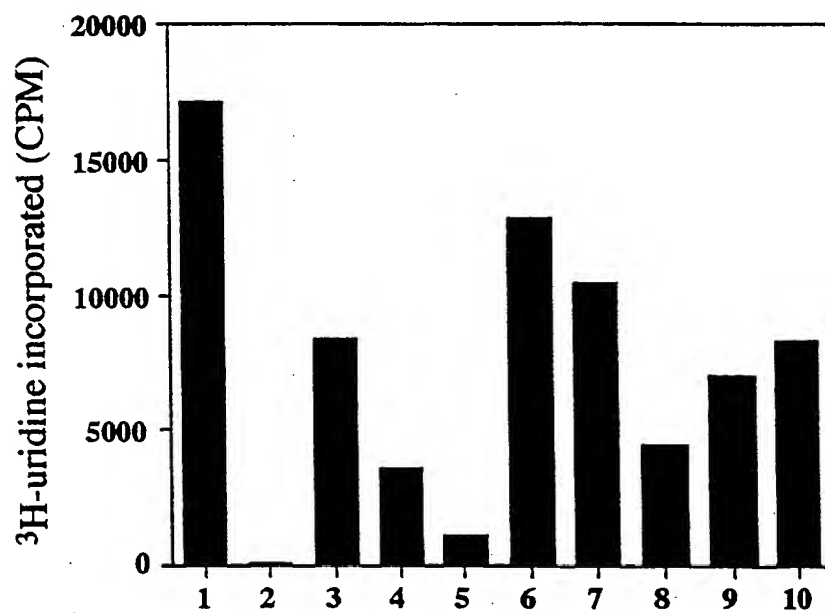
A**B**

FIGURE 8

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pACNR/BVD NADL-Xba* -> Graphic Map

DNA sequence 15065 bp gtatacgagaat ... cgactcactata circular

pACNR/BVD NADL-Xba = HaeII and XhoI digest of pACNR/BVD NADL ligated to
HaeII and XhoI digest of pACNR1180/DraIII-/BVD5'
8/27 corrected nt 12136 G to C to give HpaI site.

Co

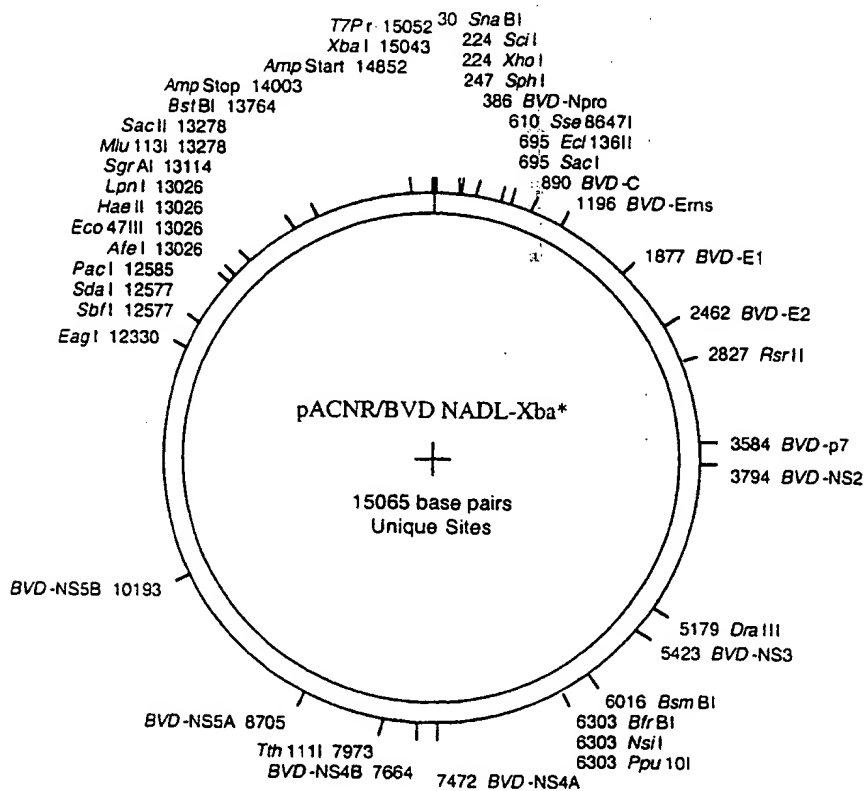


FIGURE 9

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pACNR/BVD NADL-Xba* -> Genes

DNA sequence 15065 b.p. gtatacgagaat ... cgactcactata circular

pACNR/BVD NADL-Xba = HaeII and XhoI digest of pACNR/BVD NADL ligated to

HaeII and XhoI digest of pACNR1180/DraIII-/BVD5'

8/27 corrected nt 12136 G to C to give HpaI site.

Co

```

1 gtatacgagaattagaaaaggcactcgtatacgtattgggcaattaaaaataataattaggcctagggaacaaatccctc 80
81 tcacggaaggccgaaaaggcctagccatgcccttagtaggactagcataatgaggggggtagcaacagtgggtgagttcg 160
161 ttggatggccttaagccctgagtagcagggtagtcgtcagtggttcgacgccttggaaataaagggtctcgagatgccacgtgg 240
241 acgagggcgtgccccaaagcacatcttaacctgagcgggggtcgcccaggtaaaagcaggttttaaccgactgttacgaata 320
321 cagcctgatagggtgtcgtcagaggcccactgtattgctactaaaaaatctctgctgtacatggcac ATG GAG TTG 394
1 M E L 3
395 ATC ACA AAT GAA CTT TTA TAC AAA ACA TAC AAA CAA AAA CCC GTC GGG GTG GAG GAA CCT 454
4 I T N E L L Y K T Y K Q K P V G V E E P 23
455 GTT TAT GAT CAG GCA GGT GAT CCC TTA TTT GGT GAA AGG GGA GCA GTC CAC CCT CAA TCG 514
24 V Y D Q A G D P L P G E R G A V H P Q S 43
515 ACG CTA AAG CTC CCA CAC AAG AGA GGG GAA CGC GAT GTT CCA ACC AAC TTG GCA TCC TTA 574
44 T L K L P H K R G E R D V P T N L A S L 63
575 CCA AAA AGA GGT GAC TGC AGG TCG GGT AAT AGC AGA GGA CCT GTG AGC GGG ATC TAC CTG 634
64 P K R G D C R S G N S R G P V S G I Y L 83
635 AAG CCA GGG CCA CTA TTT TAC CAG GAC TAT AAA GGT CCC GTC TAT CAC AGG GCC CCG CTG 694
84 K P G P L F Y Q D Y K G P V Y H R A P L 103
695 GAG CTC TTT GAG GAG GGA TCC ATG TGT GAA ACG ACT AAA CGG ATA GGG AGA GTA ACT GGA 754
104 E L F E E G S M C E T T K R I G R V T G 123
755 AGT GAC GGA AAG CTG TAC CAC ATT TAT GTG TGT ATA GAT GGA TGT ATA ATA AAA AGT 814
124 S D G K L Y H I Y V C I D G C I I I K S 143
815 GCC ACG AGA AGT TAC CAA AGG GTG TTC AGG TGG GTC CAT AAT AGG CTT GAC TGC CCT CTA 874
144 A T R S Y Q R V F R W V H N R L D C P L 163
875 TGG GTC ACA ACT TGC TCA GAC ACG AAA GAA GAG GGA GCA ACA AAA AAG AAA ACA CAG AAA 934
164 W V T T C S D T K E E G A T K K K T Q K 183
935 CCC GAC AGA CTA GAA AGG GGG AAA ATG AAA ATA GTG CCC AAA GAA TCT GAA AAA GAC AGC 994
184 P D R L E R G K M K I V P K E S E K D S 203
995 AAA ACT AAA CCT CCG GAT GCT ACA ATA GTG GTG GAA GGA GTC AAA TAC CAG GTG AGG AAG 1054
204 K T K P P D A T I V V E G V K Y Q V R K 223
1055 AAG GGA AAA ACC AAG AGT AAA AAC ACT CAG GAC GGC TTG TAC CAT AAC AAA AAC AAA CCT 1114
224 K G K T K S K N T Q D G L Y H N K N K P 243
1115 CAG GAA TCA CGC AAG AAA CTG GAA AAA GCA TTG TTG GCG TGG GCA ATA ATA GCT ATA GTT 1174
244 Q E S R K K L E K A L L A W A I I A I V 263
1175 TTG TTT CAA GTT ACA ATG GGA GAA AAC ATA ACA CAG TGG AAC CTA CAA GAT AAT GGG ACG 1234
264 L F Q V T M G E N I T Q W N L Q D N G T 283
1235 GAA GGG ATA CAA CGG GCA ATG TTC CAA AGG GGT GTG AAT AGA AGT TTA CAT GGA ATC TGG 1294
284 E G I Q R A M F Q R G V N R S L H G I W 303
1295 CCA GAG AAA ATC TGT ACT GGT GTC CCT TCC CAT CTA GCC ACC GAT ATA GAA CTA AAA ACA 1354
304 P E K I C T G V P S H L A T D I E L K T 323
1355 ATT CAT GGT ATG ATG GAT GCA AGT GAG AAG ACC AAC TAC ACG TGT TGC AGA CTT CAA CGC 1414
324 I H G M M D A S E K T N Y T C C R L Q R 343
1415 CAT GAG TGG AAC AAG CAT GGT TGG TGC AAC TGG TAC AAT ATT GAA CCC TGG ATT CTA GTC 1474
344 H E W N K K L E K A N Y N I E P W I L V 363
1475 ATG AAT AGA ACC CAA GCC AAT CTC ACT GAG GGA CAA CCA CCA AGG GAG TGC GCA GTC ACT 1534
364 M N R T Q A N L T E G Q P P R E C A V T 383
1535 TGT AGG TAT GAT AGG GCT AGT GAC TTA AAC GTG GTA ACA CAA GCT AGA GAT AGC CCC ACA 1594
384 C R Y D R A S D L N V V T Q A R D S P T 403
1595 CCC TTA ACA GGT TGC AAG AAA GGA AAG AAC TTC TCC TTT GCA GGC ATA TTG ATG CGG GGC 1654
404 P L T G C K K G K N F S F A G I L M R G 423

```

FIGURE 10-1

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 424 P C N F E I A A S D V L F K E H E R I S 443
 1715 ATG TTC CAG GAT ACT ACT CTT TAC CTT GTT GAC GGG TTG ACC AAC TCC TTA GAA GGT GCC 1774
 444 M F Q D T T L Y L V D G L T N S L E G A 463
 1775 AGA CAA GGA ACC GCT AAA CTG ACA ACC TGG TTA GGC AAG CAG CTC GGG ATA CTA GGA AAA 1834
 464 R Q G T A K L T T W L G K Q L G I L G K 483
 1835 AAG TTG GAA AAC AAG AGT AAG ACG TGG TTT GGA GCA TAC GCT GCT TCC CCT TAC TGT GAT 1894
 484 K L E N K S K T W F G A Y A A S P Y C D 503
 1895 GTC GAT CGC AAA ATT GGC TAC ATA TGG TAT ACA AAA AAT TGC ACC CCT GCC TGC TTA CCC 1954
 504 V D R K I G Y I W Y T K N C T P A C L P 523
 1955 AAG AAC ACA AAA ATT GTC GGC CCT GGG AAA TTT GAC ACC AAT GCA GAG GAC GGC AAG ATA 2014
 524 K N T K I V G P G K F D T N A E D G K I 543
 2015 TTA CAT GAG ATG GGG GGT CAC TTG TCG GAG GTA CTA CTA CTT TCT TTA GTG GTG CTG TCC 2074
 544 L H E M G G H L S E V L L L S L V V L S 563
 2075 GAC TTC GCA CCG GAA ACA GCT AGT GTA ATG TAC CTA ATC CTA CAT TTT TCC ATC CCA CAA 2134
 564 D F A P E T A S V M Y L I L H F S I P Q 583
 2135 AGT CAC GTT GAT GTA ATG GAT TGT GAT AAG ACC CAG TTG AAC CTC ACA GTG GAG CTG ACA 2194
 584 S H V D V M D K T Q L N L T V E L T 603
 2195 ACA GCT GAA GTA ATA CCA GGG TCG GTC TGG AAT CTA GGC AAA TAT GTA TGT ATA AGA CCA 2254
 604 T A E V I P G S V W N L G K Y V C I R P 623
 2255 AAT TGG TGG CCT TAT GAG ACA ACT GTA GTG TTG GCA TTT GAA GAG GTG AGC CAG GTG GTG 2314
 624 N W W P Y E T T V V L A F E E V S Q V V 643
 2315 AAG TTA GTG TTG AGG GCA CTC AGA GAT TTA ACA CGC ATT TGG AAC GCT GCA ACA ACT ACT 2374
 644 K L V L R A L R D L T R I W N A A T T T 663
 2375 GCT TTT TTA GTA TGC CTT GTT AAG ATA GTC AGG GGC CAG ATG GTA CAG GGC ATT CTG TGG 2434
 664 A F L V C L V K I V R G Q M V Q G I L W 683
 2435 CTA CTA TTG ATA ACA GGG GTA CAA GGG CAC TTG GAT TGC AAA CCT GAA TTC TCG TAT GCC 2494
 684 L L L I T G V Q G H L D C K P E F S Y A 703
 2495 ATA GCA AAG GAC GAA AGA ATT GGT CAA CTG GGG GCT GAA GGC CTT ACC ACC ACT TGG AAG 2554
 704 I A K D E R I G T L G A E G L T T T W K 723
 2555 GAA TAC TCA CCT GGA ATG AAG CTG GAA GAC ACA ATG GTC ATT GCT TGG TGC GAA GAT GGG 2614
 724 E Y S P G M K L E D T M V I A W C E D G 743
 2615 AAG TTA ATG TAC CTC CAA AGA TGC ACG AGA GAA ACC AGG TAT CTC GCA ATC TTG CAT ACA 2674
 744 K L M Y L Q R C T R E T R Y L A I L H T 763
 2675 AGA GCC TTG CCG ACC AGT GTG GTA TTC AAA AAA CTC TTT GAT GGG CGA AAG CAA GAG GAT 2734
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 784 V V E M N D N F E F G L C P C D A K P I 803
 2795 GTA AGA GGG AAG TTC AAT ACA ACG CTG CTG AAC GGA CCG GCC TTC CAG ATG GTA TGC CCC 2854
 804 V R G K F N T T L L N G P A F Q M V C P 823
 2855 ATA GGA TGG ACA GGG ACT GTA AGC TGT ACG TCA TTT AAT ATG GAC ACC TTA GCC ACA ACT 2914
 824 I G W T G T V S C T S F N M D T L A T 843
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 844 V V R T Y R R S K P F P H R Q G C I T Q 863
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FIGURE 10-2

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 3695 GTA AAG AAG TGG GTC TTA CTC TTA TAC CAC ATC TTA GTG GTA CAC CCA ATC AAA TCT GTA 3754
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 3755 ATT GTG ATC CTA CTG ATG ATT GGG GAT GTG GTA AAG GCC GAT TCA GGG GGC CAA GAG TAC 3814
 1124 I V I L L M I G D V V K A D S G Q E Y 1143
 3815 TTG GGG AAA ATA GAC CTC TGT TTT ACA ACA GTA GTA CTA ATC GTC ATA GGT TTA ATC ATA 3874
 1144 L G K I D L C F T T V V L I V I G L I I 1163
 3875 GCC AGG CGT GAC CCA ACT ATA GTG CCA CTG GTA ACA ATA ATG GCA GCA CTG AGG GTC ACT 3934
 1164 A R R D P T I V P L V T I M A A L R V T 1183
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 1184 E L T H Q P G V D I A V A V M T I T L L 1203
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 1224 L V S A V F L I R S L I Y L G R I E M P 1243
 4115 GAG GTA ACT ATC CCA AAC TGG AGA CCA CTA ACT TTA ATA CTA TTA TAT TTG ATC TCA ACA 4174
 1244 E V T I P N W R P L T L I L L Y L I S T 1263
 4175 ACA ATT GTA ACG AGG TGG AAG GTT GAC GTG GCT GGC CTA TTG TTG CAA TGT GTG CCT ATC 4234
 1264 T I V T R W K V D V A G G L L L Q C V P I 1283
 4235 TTA TTG CTG GTC ACA ACC TTG TGG GCC GAC TTC TTA ACC CTA ATA CTG ATC CTG CCT ACC 4294
 1284 L L L V T T L W A D F L T L I L I L P T 1303
 4295 TAT GAA TTG GTT AAA TTA TAC TAT CTG AAA ACT GTT AGG ACT GAT ATA GAA AGA AGT TGG 4354
 1304 Y E L V K L Y Y L K T V R T D I E R S W 1323
 4355 CTA GGG GGG ATA GAC TAT ACA AGA GTT GAC TCC ATC TAC GAC GTT GAT GAG AGT GGA GAG 4414
 1324 L G G I D Y T R V D S I Y D V D E S G E 1343
 4415 GGC GTA TAT CTT TTT CCA TCA AGG CAG AAA GCA CAG GGG AAT TTT TCT ATA CTC TTG CCC 4474
 1344 G V Y L F P S R Q K A Q G N F S I L L P 1363
 4475 CTT ATC AAA GCA ACA CTG ATA AGT TGC GTC AGC AGT AAA TGG CAG CTA ATA TAC ATG AGT 4534
 1364 L I K A T L I S C V S S K W Q L I Y M S 1383
 4535 TAC TTA ACT TTG GAC TTT ATG TAC TAC ATG CAC AGG AAA GTT ATA GAA GAG ATC TCA GGA 4594
 1384 Y L T L D F M Y Y M H R K V I E E I S G 1403
 4595 GGT ACC AAC ATA ATA TCC AGG TTA GTG GCA GCA CTC ATA GAG CTG AAC TGG TCC ATG GAA 4654
 1404 G T N I I S R L V A A L I E L N W S M E 1423
 4655 GAA GAG GAG AGC AAA GGC TTA AAG AAG TTT TAT CTA TTG TCT GGA AGG TTG AGA AAC CTA 4714
 1424 E E E S K G L K K F Y L L S G R L R N L 1443
 4715 ATA ATA AAA CAT AAG GTA AGG AAT GAG ACC GTG GCT TCT TGG TAC GGG GAG GAG GAA GTC 4774
 1444 I I K H K V R N E T V A S W Y G E E E V 1463
 4775 TAC GGT ATG CCA AAG ATC ATG ACT ATA ATC AAG GCC AGT ACA CTG AGT AAG AGC AGG CAC 4834
 1464 Y G M P K I M T I I K A S T L S K S R H 1483
 4835 TGC ATA ATA TGC ACT GTA TGT GAG GGC CGA GAG TGG AAA GGT GGC ACC TGC CCA AAA TGT 4894
 1484 C I C T V C E G R E W K G T C P K C 1503
 4895 GGA CGC CAT GGG AAG CCG ATA ACG TGT GGG ATG TCG CTA GCA GAT TTT GAA GAA AGA CAC 4954
 1504 G R H G K P I T C G M S L A D F E E R H 1523
 4955 TAT AAA AGA ATC TTT ATA AGG GAA GGC AAC TTT GAG GGT ATG TGC AGC CGA TGC CAG GGA 5014
 1524 Y K R I F I R E G N F E G M C S R C Q G 1543
 5015 AAG CAT AGG AGG TTT GAA ATG GAC CGG GAA CCT AAG AGT GCC AGA TAC TGT GCT GAG TGT 5074
 1544 K H R R F E M D R E P K S A R Y C A E C 1563
 5075 AAT AGG CTG CAT CCT GCT GAG GAA GGT GAC TTT TGG GCA GAG TCG AGC ATG TTG GGC CTC 5134
 1564 N R L H P A E E G D F W A E S S M L G L 1583

FIGURE 10-3

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5135 AAA ATC ACC TAC TTT GCG CTG ATG GAT GGA AAG GTG TAT GAT ATC ACA GAG TGG GCT GGA 5194
 1584 K I T Y F A L M D G K V Y D I T E W A G 1603
 5195 TGC CAG CGT GTG GGA ATC TCC CCA GAT ACC CAC AGA GTC CCT TGT CAC ATC TCA TTT GGT 5254
 1604 C Q R V G I S P D T H R V P C H I S F G 1623
 5255 TCA CGG ATG CCT TTC AGG CAG GAA TAC AAT GGC TTT GTA CAA TAT ACC GCT AGG GGG CAA 5314
 1624 S R M P F R Q E Y N G F V Q Y T A R G Q 1643
 5315 CTA TTT CTG AGA AAC TTG CCC GTA CTG GCA ACT AAA GTA AAA ATG CTC ATG GTA GGC AAC 5374
 1644 L F L R N L P V L A T K V K M L M V G N 1663
 5375 CTT GGA GAA GAA ATT GGT AAT CTG GAA CAT CTT GGG TGG ATC CTA AGG GGG CCT GCC GTG 5434
 1664 L G E E I G N L E H L G W I L R G P A V 1683
 5435 TGT AAG AAG ATC ACA GAG CAC GAA AAA TGC CAC ATT AAT ATA CTG GAT AAA CTA ACC GCA 5494
 1684 C K K I T E H E K C H I N I L D K L 1703
 5495 TTT TTC GGG ATC ATG CCA AGG GGG ACT ACA CCC AGA GCC CCG GTG AGG TTC CCT ACG AGC 5554
 1704 F F G R I M P R G T T C P R A P V R F P T S 1723
 5555 TTA CTA AAA GTG AGG AGG GGT CTG GAG ACT GCC TGG GCT TAC ACA CAC CAA GGC GGG ATA 5614
 1724 L L K V R R G L E T A W A Y T H Q G G I 1743
 5615 AGT TCA GTC GAC CAT GTA ACC GCC GGA AAA GAT CTA CTG GTC TGT GAC AGC ATG GGA CGA 5674
 1744 S S V D H V T A G K D L L V C D S M G R 1763
 5675 ACT AGA GTG GTT TGC CAA AGC AAC AAC AGG TTG ACC GAT GAG ACA GAG TAT GGC GTC AAG 5734
 1764 T R V V C Q S N N R L T D E T E Y G V K 1783
 5735 ACT GAC TCA GGG TGC CCA GAC GGT GCC AGA TGT TAT GTG TTA AAT CCA GAG GCC GTT AAC 5794
 1784 T D S G C P D G A R C Y V L N P E A V N 1803
 5795 ATA TCA GGA TCC AAA GGG GCA GTC GTT CAC CTC CAA AAG ACA GGT GGA GAA TTC ACG TGT 5854
 1804 I S G S K G A V V H L Q T G G E F T C 1823
 5855 GTC ACC GCA TCA GGC ACA CCG GCT TTC TTC GAC CTA AAA AAC TTG AAA GGA TGG TCA GGC 5914
 1824 V T A S G T P A F T F D L K N L K G W S G 1843
 5915 TTG CCT ATA TTT GAA GCC TCC AGC GGG AGG GTG GTT GGC AGA GTC AAA GTA GGG AAG AAT 5974
 1844 L P I F E A S S G R V V G R V K V G K N 1863
 5975 GAA GAG TCT AAA CCT ACA AAA ATA ATG AGT GGA ATC CAG ACC GTC TCA AAA AAC AGA GCA 6034
 1864 E E S K P T K I M S G I Q T V S K N R A 1883
 6035 GAC CTG ACC GAG ATG GTC AAG AAG ATA ACC AGC ATG AAC AGG GGA GAC TTC AAG CAG ATT 6094
 1884 D L T E M V K K I T S M N R G D F K Q I 1903
 6095 ACT TTG GCA ACA GGG GCA GGC AAA ACC ACA GAA CTC CCA AAA GCA GTT ATA GAG GAG ATA 6154
 1904 T L A T G A G K T T E L P K A V I E E I 1923
 6155 GGA AGA CAC AAG AGA GTA TTA GTT CTT ATA CCA TTA AGG GCA GCG GCA GAG TCA GTC TAC 6214
 1924 G R H K R V L V L I P L R A A A E S V Y 1943
 6215 CAG TAT ATG AGA TTG AAA CAC CCA AGC ATC TCT TTT AAC CTA AGG ATA GGG GAC ATG AAA 6274
 1944 Q Y M R L K H P S I S F N L R I G D M K 1963
 6275 GAG GGG GAC ATG GCA ACC GGG ATA ACC TAT GCA TCA TAC GGG TAC TTC TGC CAA ATG CCT 6334
 1964 E G D M A T G I T Y A S Y G Y F C Q M P 1983
 6335 CAA CCA AAG CTC AGA GCT GCT ATG GTA GAA TAC TCA TAC ATA TTC TTA GAT GAA TAC CAT 6394
 1984 Q P K L R A A M V E Y S Y I F L D E Y H 2003
 6395 TGT GCC ACT CCT GAA CAA CTG GCA ATT ATC GGG AAG ATC CAC AGA TTT TCA GAG AGT ATA 6454
 2004 C A T P E Q L A I I G K I H R F S E S I 2023
 6455 AGG GTT GTC GCC ATG ACT GCC ACG CCA GCA GGG TCG GTG ACC ACA ACA GGT CAA AAG CAC 6514
 2024 R V V A M T A T P A G S V T T T G Q K H 2043
 6515 CCA ATA GAG GAA TTC ATA GCC CCC GAG GTA ATG AAA GGG GAG GAT CTT GGT AGT GAT TTC 6574
 2044 P I E E F I A P E V M K G G E D L G S Q F 2063
 6575 CTT GAT ATA GCA GGG TTA AAA ATA CCA GTG GAT GAG ATG AAA GGC AAT ATG TTG GTT TTT 6634
 2064 L D I A G L K I P V D E M K G N M L V F 2083
 6635 GTA CCA ACG AGA AAC ATG GCA GTA GAG GTA GCA AAG AAG CTA AAA GCT AAG GGC TAT AAC 6694
 2084 V P T R N M A V E V A K K L K A K G Y N 2103
 6695 TCT GGA TAC TAT TAC AGT GGA GAG GAT CCA GCC AAT CTG AGA GTT GTG ACA TCA CAA TCC 6754
 2104 S G Y Y Y S G E D P A N L R V V T S Q S 2123
 6755 CCC TAT GTA ATC GTG GCT ACA AAT GCT ATT GAA TCA GGA GTG ACA CTA CCA GAT TTG GAC 6814
 2124 P Y V I V A T N A I E S G V T L P D L D 2143
 6815 ACG GTT ATA GAC ACG GGG TTG AAA TGT GAA AAG AGG GTG AGG GTA TCA TCA AAG ATA CCC 6874
 2144 T V I D T G L K C E K R V R V S S K I P 2163

FIGURE 10-4

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6875 TTC ATC GTA ACA GGC CTT AAG AGG ATG GCC GTG ACT GTG GGT GAG CAG GCG CAG CGT AGG 6934
 2164 F I V T G L K R M A V T T G E Q A Q R R 2183
 6935 GGC AGA GTA GGT AGA GTG AAA CCC GGG AGG TAT TAT AGG AGC CAG GAA ACA GCA ACA GGG 6994
 2184 G R V G R V K P G R Y Y R S Q E T A T G 2203
 6995 TCA AAG GAC TAC CAC TAT GAC CTC TTG CAG GCA CAA AGA TAC GGG ATT GAG GAT GGA ATC 7054
 2204 S K D Y H Y D L L Q A Q R Y G I E D G I 2223
 7055 AAC GTG ACG AAA TCC TTT AGG GAG ATG AAT TAC GAT TGG AGC CTA TAC GAG GAG GAC AGC 7114
 2224 N V T K S F R E M N Y D W S L Y E E D S 2243
 7115 CTA CTA ATA ACC CAG CTG GAA ATA CTA AAT AAT CTA CTC ATC TCA GAA GAC TTG CCA GCC 7174
 2244 L L I T Q L E I L N N L L I S E D L P A 2263
 7175 GCT GTT AAG AAC ATA ATG GCC AGG ACT GAT CAC CCA GAG CCA ATC CAA CTT GCA TAC AAC 7234
 2264 A V K N I M A R T D H P E P I Q L A Y N 2283
 7235 AGC TAT GAA GTC CAG GTC CCG GTC CTG TTC CCA AAA ATA AGG AAT GGA GAA GTC ACA GAC 7294
 2284 S Y E V Q V P V L F P K I R N G E V T D 2303
 7295 ACC TAC GAA AAT TAC TCG TTT CTA AAT GCC AGA AAG TTA GGG GAG GAT GTG CCC GTG TAT 7354
 2304 T Y E N Y S F L N A R K L G E D V P V Y 2323
 7355 ATC TAC GCT ACT GAA GAT GAG GAT CTG GCA GTT GAC CTC TTA GGG CTA GAC TGG CCT GAT 7414
 2324 I Y A T E D E D L A V D L L G L D W P D 2343
 7415 CCT GGG AAC CAG CAG GTA GTG GAG ACT GGT AAA GCA CTG AAG CAA GTG ACC GGG TTG TCC 7474
 2344 P G N Q Q V V E T G K A L K Q V T G L S 2363
 7475 TCG GCT GAA AAT GCC CTA CTA GTG GCT TTA TTT GGG TAT GTG GGT TAC CAG GCT CTC TCA 7534
 2364 S A E N A L L V A L F G Y V G Y Q A L S 2383
 7535 AAG AGG CAT GTC CCA ATG ATA ACA GAC ATA TAT ACC ATC GAG GAC CAG AGA CTA GAA GAC 7594
 2384 K R H V P M I T D I Y T I E D Q R L E D 2403
 7595 ACC ACC CAC CTC CAG TAT GCA CCC AAC GCC ATA AAA ACC GAT GGG ACA GAG ACT GAA CTG 7654
 2404 T T H L Q Y A P N A I K T D G T E T E L 2423
 7655 AAA GAA CTG GCG TCG GGT GAC GTG GAA AAA ATC ATG GGA GCC ATT TCA GAT TAT GCA GCT 7714
 2424 K E L A S G D V E K I M G A I S D Y A A 2443
 7715 GGG GGA CTG GAG TTT GTT AAA TCC CAA GCA GAA AAG ATA AAA ACA GCT CCT TTG TTT AAA 7774
 2444 G G L E F V K S Q A E K I K T A P L F K 2463
 7775 GAA AAC GCA GAA GCC GCA AAA GGG TAT GTC CAA AAA TTC ATT GAC TCA TTA ATT GAA AAT 7834
 2464 E N A E A A K G Y V Q K F I D S L I E N 2483
 7835 AAA GAA GAA ATA ATC AGA TAT GGT TTG TGG GGA ACA CAC ACA GCA CTA TAC AAA AGC ATA 7894
 2484 K E E I I R Y G L W G T H T A L Y K S I 2503
 7895 GCT GCA AGA CTG GGG CAT GAA ACA GCG TTT GCC ACA CTA GTG TTA AAG TGG CTA GCT TTT 7954
 2504 A A R L G H E T A F A T L V L K W L A F 2523
 7955 GGA GGG GAA TCA GTG TCA GAC CAC GTC AAG CAG GCG GCA GTT GAT TTA GTG GTC TAT TAT 8014
 2524 G G E S V S D H V K Q A A V D L V Y Y 2543
 8015 GTG ATG AAT AAG CCT TCC TTC CCA GGT GAC TCC GAG ACA CAG CAA GAA GGG AGG CGA TTC 8074
 2544 V M N K P S F P G D S E T Q Q E G R R F 2563
 8075 GTC GCA AGC CTG TTC ATC TCC GCA CTG GCA ACC TAC ACA TAC AAA ACT TGG AAT TAC CAC 8134
 2564 V A S L F I S A L A T Y T Y K T W N Y H 2583
 8135 AAT CTC TCT AAA GTG GTG GAA CCA GCC CTG GCT TAC CTC CCC TAT GCT ACC AGC GCA TTA 8194
 2584 N L S K V V E P A L A Y L P Y A T S A L 2603
 8195 AAA ATG TTC ACC CCA ACG CGG CTG GAG AGC GTG GTG ATA CTG AGC ACC ACG ATA TAT AAA 8254
 2604 K M F T P T R L E S V V I L S T T I Y K 2623
 8255 ACA TAC CTC TCT ATA AGG AAG GGG AAG AGT GAT GGA TTG CTG GGT ACG GGG ATA AGT GCA 8314
 2624 T Y L S I R K G K S D G L L G T G I S A 2643
 8315 GCC ATG GAA ATC CTG TCA CAA AAC CCA GTA TCG GTA GGT ATA TCT GTG ATG TTG GGG GTA 8374
 2644 A M E I L S Q N P V S V G I S V M L G V 2663
 8375 GGG GCA ATC GCT GCG CAC AAC GCT ATT GAG TCC AGT GAA CAG AAA AGG ACC CTA CTT ATG 8434
 2664 G A I A A H N A I E S S E Q K R T L L M 2683
 8435 AAG GTG TTT GTA AAG AAC TTC TTG GAT CAG GCT GCA ACA GAT GAG CTG GTA AAA GAA AAC 8494
 2684 K V F V K N F L D Q A A T D E L V K E N 2703
 8495 CCA GAA AAA ATT ATA ATG GCC TTA TTT GAA GCA GTC CAG ACA ATT GGT AAC CCC CTG AGA 8554
 2704 P E K I I M A L F E A V Q T I G N P L R 2723
 8555 CTA ATA TAC CAC CTG TAT GGG GTT TAC TAC AAA GGT TGG GAG GCC AAG GAA CTA TCT GAG 8614
 2724 L I Y H L Y G V Y Y K G W E A K E L S E 2743

FIGURE 10-5

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8615 AGG ACA GCA GGC AGA AAC TTA TTC ACA TTG ATA ATG TTT GAA GCC TTC GAG TTA TTA GGG 8674
 2744 R T A G R N L F T L I M F E A F E L L G 2763
 8675 ATG GAC TCA CAA GGG AAA ATA AGG AAC CTG TCC GGA AAT TAC ATT TTG GAT TTG ATA TAC 8734
 2764 M D S Q G K I R N L S G N Y I L D L I Y 2783
 8735 GGC CTA CAC AAG CAA ATC AAC AGA GGG CTG AAG AAA ATG GTA CTG GGG TGG GCC CCT GCA 8794
 2784 G L H K Q I N R G L K K M V L G W A P A 2803
 8795 CCC TTT AGT TGT GAC TGG ACC CCT AGT GAC GAG AGG ATC AGA TTG CCA ACA GAC AAC TAT 8854
 2804 P F S C D W T P S D E R I R L P T D N Y 2823
 8855 TTG AGG GTA GAA ACC AGG TGC CCA TGT GGC TAT GAG ATG AAA GCT TTC AAA AAT GTA GGT 8914
 2824 L R V E T R C P C G Y E M K A F K N V G 2843
 8915 GGC AAA CTT ACC AAA GTG GAG GAG AGC GGG CCT TTC CTA TGT AGA AAC AGA CCT GGT AGG 8974
 2844 G K L T K V E E S G P F L C R N R P G R 2863
 8975 GGA CCA GTC AAC TAC AGA GTC ACC AAG TAT TAC GAT GAC AAC CTC AGA GAG ATA AAA CCA 9034
 2864 G P V N Y R V T K Y Y D D N L R E I K P 2883
 9035 GTA GCA AAG TTG GAA GGA CAG GTA GAG CAC TAC TAC AAA GGG GTC ACA GCA AAA ATT GAC 9094
 2884 V A K L E G Q V E H Y Y K G V T A K I D 2903
 9095 TAC AGT AAA GGA AAA ATG CTC TTG GCC ACT GAC AAG TGG GAG GTG GAA CAT GGT GTC ATA 9154
 2904 Y S K G K M L L A T D K W E V E H G V I 2923
 9155 ACC AGG TTA GCT AAG AGA TAT ACT GGG GTC GGG TTC AAT GGT GCA TAC TTA GGT GAC GAG 9214
 2924 T R L A K R Y T G V G F N G A Y L G D E 2943
 9215 CCC AAT CAC CGT GCT CTA GTG GAG AGG GAC TGT GCA ACT ATA ACC AAA AAC ACA GTA CAG 9274
 2944 P N H R A L V E R D C A T I T K N T V Q 2963
 9275 TTT CTA AAA ATG AAG AAG GGG TGT GCG TTC ACC TAT GAC CTG ACC ATC TCC AAT CTG ACC 9334
 2964 F L K M K K G C A F T Y D L T I S N L T 2983
 9335 AGG CTC ATC GAA CTA GTA CAC AGG AAC AAT CTT GAA GAG AAG GAA ATA CCC ACC GCT ACG 9394
 2984 R L I E L V H R N N L E E K E I P T A T 3003
 9395 GTC ACC ACA TGG CTA GCT TAC ACC TTC GTG AAT GAA GAC GTA GGG ACT ATA AAA CCA GTA 9454
 3004 V T T W L A Y T F V N E D V G T I K P V 3023
 9455 CTA GGA GAG AGA GTA ATC CCC GAC CCT GTA GTT GAT ATC AAT TTA CAA CCA GAG GTG CAA 9514
 3024 L G E R V I P D P V V D I N L Q P E V Q 3043
 9515 GTG GAC ACG TCA GAG GTT GGG ATC ACA ATA ATT GGA AGG GAA ACC CTG ATG ACA ACG GGA 9574
 3044 V D T S E V G I T I I G R E T L M T T G 3063
 9575 GTG ACA CCT GTC TTG GAA AAA GTA GAG CCT GAC GCC AGC GAC AAC CAA AAC TCG GTG AAG 9634
 3064 V T P V L E K V E P D A S D N Q N S V K 3083
 9635 ATC GGG TTG GAT GAG GGT AAT TAC CCA GGG CCT GGA ATA CAG ACA CAT ACA CTA ACA GAA 9694
 3084 I G L D E G N Y P G P G I Q T H T L T E 3103
 9695 GAA ATA CAC AAC AGG GAT GCG AGG CCC TTC ATC ATG ATC CTG GGC TCA AGG AAT TCC ATA 9754
 3104 E I H N R D A R P F I M I L G S R N S I 3123
 9755 TCA AAT AGG GCA AAG ACT GCT AGA AAT ATA AAT CTG TAC ACA GGA AAT GAC CCC AGG GAA 9814
 3124 S N R A K T A R N I N L Y T G N D P R E 3143
 9815 ATA CGA GAC TTG ATG GCT GCA GGG CGC ATG TTA GTA GTA GCA CTG AGG GAT GTC GAC CCT 9874
 3144 I R D L M A A G R M L V V A L R D V D P 3163
 9875 GAG CTG TCT GAA ATG GTC GAT TTC AAG GGG ACT TTT TTA GAT AGG GAG GCC CTG GAG GCT 9934
 3164 E L S E M V D F K G T F L D R E A L E A 3183
 9935 CTA AGT CTC GGG CAA CCT AAA CCG AAG CAG GTT ACC AAG GAA GCT GTT AGG AAT TTG ATA 9994
 3184 L S L G Q P K P K Q V T K E A V R N L I 3203
 9995 GAA CAG AAA AAA GAT GTG GAG ATC CCT AAC TGG TTT GCA TCA GAT GAC CCA GTA TTT CTG 10054
 3204 E G K K D V E I P N W F A S D D P V L 3223
 10055 GAA GTG GCC TTA AAA AAT GAT AAG TAC TAC TTA GTA GGA GAT GTT GGA GAG CTA AAA GAT 10114
 3224 E V A L K N D K Y Y L V G D V G E L K D 3243
 10115 CAA GCT AAA GCA CTT GGG GCC ACG GAT CAG ACA AGA ATT ATA AAG GAG GTA GGC TCA AGG 10174
 3244 Q A K A L G A T D Q T R I I K E V G S R 3263
 10175 ACG TAT GCC ATG AAG CTA TCT AGC TGG TTC CTC AAG GCA TCA AAC AAA CAG ATG AGT TTA 10234
 3264 T Y A M K L S S W F L K A S N K Q M S L 3283
 10235 ACT CCA CTG TTT GAG GAA TTG TTG CTA CGG TGC CCA CCT GCA ACT AAG AGC AAT AAG GGG 10294
 3284 T P L F E E L L L R C P P A T K S N K G 3303
 10295 CAC ATG GCA TCA GCT TAC CAA TTG GCA CAG GGT AAC TGG GAG CCC CTC GGT TGC GGG GTG 10354
 3304 H M A S A Y Q L A Q G N W E P L G C G V 3323

FIGURE 10-6

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10355 CAC CTA GGT ACA ATA CCA GCC AGA AGG GTG AAG ATA CAC CCA TAT GAA GCT TAC CTG AAG 10414
 3324 H L G T I P A R R V K I H P Y E A Y L K 3343
 10415 TTG AAA GAT TTC ATA GAA GAA GAG AAG AAA CCT AGG GTT AAG GAT ACA GTA ATA AGA 10474
 3344 L K D F I E E E E K K P R V K D T V I R 3363
 10475 GAG CAC AAC AAA TGG ATA CTT AAA AAA ATA AGG TTT CAA GGA AAC CTC AAC ACC AAG AAA 10534
 3364 E H N K W I L K K I R F Q G N L N T K K 3383
 10535 ATG CTC AAC CCG GGG AAA CTA TCT GAA CAG TTG GAC AGG GAG GGG CGC AAG AGG AAC ATC 10594
 3384 M L N P G K L S E Q L D R E G R K R N I 3403
 10595 TAC AAC CAC CAG ATT GGT ACT ATA ATG TCA AGT GCA GGC ATA AGG CTG GAG AAA TTG CCA 10654
 3404 Y N H Q I G T I M S S A G I R L E K L P 3423
 10655 ATA GTG AGG GCC CAA ACC GAC ACC AAA ACC TTT CAT GAG GCA ATA AGA GAT AAG ATA GAC 10714
 3424 I V R A Q T D T K T F H E A I R D K I D 3443
 10715 AAG AGT GAA AAC CGG CAA AAT CCA GAA TTG CAC AAC AAA TTG TTG GAG ATT TTC CAC ACG 10774
 3444 K S E N R Q N P E L H N K L L E I F H T 3463
 10775 ATA GCC CAA CCC ACC CTG AAA CAC ACC TAC GGT GAG GTG ACG TGG GAG CAA CTT GAG GCG 10834
 3464 I A Q P T L K H T Y G E V T W E Q L E A 3483
 10835 GGG ATA AAT AGA AAG GGG GCA GCA GGC TTC CTG GAG AAG AAG AAC ATC GGA GAA GTA TTG 10894
 3484 G I N R K G A A G F L E K K N I G E V L 3503
 10895 GAT TCA GAA AAG CAC CTG GTA GAA CAA TTG GTC AGG GAT CTG AAG GCC GGG AGA AAG ATA 10954
 3504 D S E K H L V E Q L V R D L K A G R K I 3523
 10955 AAA TAT TAT GAA ACT GCA ATA CCA AAA AAT GAG AAG AGA GAT GTC AGT GAT GAC TGG CAG 11014
 3524 K Y Y E T A I P K N E K R D V S D D W Q 3543
 11015 GCA GGG GAC CTG GTG GTT GAG AAG AGG CCA AGA GTT ATC CAA TAC CCT GAA GCC AAG ACA 11074
 3544 A G D L V V E K R P R V I Q Y P E A K T 3563
 11075 AGG CTA GCC ATC ACT AAG GTC ATG TAT AAC TGG GTG AAA CAG CAG CCC GTT GTG ATT CCA 11134
 3564 R L A I T K V M Y N W V K Q P V V I P 3583
 11135 GGA TAT GAA GGA AAG ACC CCC TTG TTC AAC ATC TTT GAT AAA GTG AGA AAG GAA TGG GAC 11194
 3584 G Y E G K T L F N I F D K V R K E W D 3603
 11195 TCG TTC AAT GAG CCA GTG GCC GTA AGT TTT GAC ACC AAA GCC TGG GAC ACT CAA GTG ACT 11254
 3604 S F N E P V A V S F D T K A W D T Q V T 3623
 11255 AGT AAG GAT CTG CAA CTT ATT GGA GAA ATC CAG AAA TAT TAC TAT AAG AAG GAG TGG CAC 11314
 3624 S K D L Q L I G E I Q K Y Y Y K K E W H 3643
 11315 AAG TTC ATT GAC ACC ATC ACC GAC CAC ATG ACA GAA GTA CCA GTT ATA ACA GCA GAT GGT 11374
 3644 K F I D T I T D H M T E V P V I T A D G 3663
 11375 GAA GTA TAT ATA AGA AAT GGG CAG AGA GGG AGC GGC CAG CCA GAC ACA AGT GCT GGC AAC 11434
 3664 E V Y I R N G Q R G S G Q P D T S A G N 3683
 11435 AGC ATG TTA AAT GTC CTG ACA ATG ATG TAC GGC TTC TGC GAA AGC ACA GGG GTA CCG TAC 11494
 3684 S M L N V L T M M Y G F C E S T G V P Y 3703
 11495 AAG AGT TTC AAC AGG GTG GCA AGG ATC CAC GTC TGT GGG GAT GAT GGC TTC TTA ATA ACT 11554
 3704 K S F N R V A R I H V C G D D G F L I T 3723
 11555 GAA AAA GGG TTA GGG CTG AAA TTT GCT AAC AAA GGG ATG CAG ATT CTT CAT GAA GCA GGC 11614
 3724 E K G L G L K F A N K G M Q I L H E A G 3743
 11615 AAA CCT CAG AAG ATA ACG GAA GGG GAA AAG ATG AAA GTT GCC TAT AGA TTT GAG GAT ATA 11674
 3744 K P Q K I T E G E K M K V A Y R F E D I 3763
 11675 GAG TTC TGT TCT CAT ACC CCA GTC CCT GTT AOG TGG TCC GAC AAC ACC AGT AGT CAC ATG 11734
 3764 E F C S H T P V P V R W S D N T S S H M 3783
 11735 GCC GGG AGA GAC ACC GCT GTG ATA CTA TCA AAG ATG GCA ACA AGA TTG GAT TCA AGT GGA 11794
 3784 A G R D T A V I L S K M A T R L D S S G 3803
 11795 GAG AGG GGT AAT ACA GCA TAT GAA AAA GCG GTA GCC TTC AGT TTC TTG CTG ATG TAT TCC 11854
 3804 E R G T A Y E K A V A F S F L M Y S 3823
 11855 TGG AAC CCG GTT AGG AGG ATT TGC CTG TTG GTC CTT TCG CAA CAG CCA GAG ACA GAC 11914
 3824 W N P L V R R I C L L V L S Q Q P E T D 3843
 11915 CCA TCA AAA CAT GCC ACT TAT TAT TAC AAA GGT GAT CCA ATA GGG GCC TAT AAA GAT GTA 11974
 3844 P S K H A T Y Y Y K G D P I G A Y K D V 3863
 11975 ATA GGT CGG AAT CTA AGT GAA CTG AAG AGA ACA GGC TTT GAG AAA TTG GCA AAT CTA AAC 12034
 3864 I G R N L S E L K R T G F E K L A N L N 3883
 12035 CTA AGC CTG TCC ACG TTG GGG ATC TGG ACT AAG CAC ACA AGC AAA AGA ATA ATT CAG GAC 12094
 3884 L S L S T L G I W T K H T S K R I I Q D 3903

FIGURE 10-7

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12095 TGT GTT GCC ATT GGG AAA GAA GAG GGC AAC TGG CTA GTT AAC GCC GAC AGG CTG ATA TCC 12154
 3904 C V A I G K E E G N W L V N A D R L I S 3923
 12155 AGC AAA ACT GGC CAC TTA TAC ATA CCT GAT AAA GGC TTT ACA TTA CAA GGA AAG CAT TAT 12214
 3924 S K T G H L Y I P D K G F T L Q G K H Y 3943
 12215 GAG CAA CTG CAG CTA AGA ACA GAG ACA AAC CCG GTC ATG GGG GTT GGG ACT GAG AGA TAC 12274
 3944 E Q L Q L R T E T N P V M G V G T E R Y 3963
 12275 AAG TTA GGT CCC ATA GTC AAT CTG CTG CTG AGA AGG TTG AAA ATT CTG CTC ATG ACG GCC 12334
 3964 K L G P I V N L L L R R L K I L L M T A 3983
 12335 GTC GGC GTC AGC AGC TGA gacaaaatgtatatattgtaataaataatccatgtacatagtgatatataaatat 12408
 3984 V G V S S S 3989
 12409 agttgggaccgtccacctcaagaagacgacacgcccacacgcagcctaacagtagtcaagattatctacctcaagat 12488
 12489 aacactacatttaatagcacacagcacttttagctgtatgaggatagcggcgacgtctatagttggactaggggaagacctct 12568
 12569 aacagccccctgcaggttaattaacttagtgggaataacgcggggtatgccggttttagcatattgacgacccaattctca 12648
 12649 cgtttgacagccttatcatcgctcgagcaagacgtttcccggtgaatatggctcataacacccttctgattactgtttatgt 12728
 12729 aagcagacagcttttattgttcatgatgatataattttatcttgtgcaatgaacatcagagattttgagacacgtggctt 12808
 12809 tgttgataaaatcgaacttttctgctgagttgaaggatcagatcacgcactctcccgacaacgcagaccgttccgtggcaaa 12888
 12889 gcaaaagtccaaatcaccaactgtgtccacctacaacaaagctctcatcaaccggtggctccctcactttctggctggatg 12968
 12969 atggggcgattcaggcctgggtatgagtcagcaacaccttcttcacgaggcagacctcagcgctagcggagtgatactgg 13048
 13049 cttactatgttggcactgatgaggggtgcagtgagtgcttcatgtggcaggagaaaaaggctgcacgggtgcgtcagc 13128
 13129 agaatatgtgatacaggatataattccgcttctctcgctcactgactcgctacgctcggtcggttcgactcggcgagcggaa 13208
 13209 atggcttacgaacggggcgagatttccctggaagatgccaggaagatacttaacaggggaagtgagagggcgcgcaaaag 13288
 13289 ccgtttttccataggctccgcccccttgacaagcatcacgaaatctgacgctcaaatcagtggtggcgaaacccgcagcag 13368
 13369 actataaagataaccaggcgtttcccttggcggttccctcgctcgctctcctgttcttgcctttcggtttaccggtgtcat 13448
 13449 tccgctgttattggcgcggtttgtctctattccacgctgacactcagttccgggttaggcagttcgctccaagctggactgt 13528
 13529 atgcacgaaccccccggttcagtcggaccgctgcgccttatccggtaactatcgctcttgagtcgaacccggaaagacatgc 13608
 13609 aaaagcaccactggcagcagccactggtaattgatttagaggagtttagtcttgaagtcagcgccggttaaggctaaact 13688
 13689 gaaaggacaagttttggtgactgcgctcctccaagccagttacctcggttcaaaagagttggtagctcagagaaacttcga 13768
 13769 aaaacggcccttgaaggcggttttttctgttttcagagcaagagattacgcgcagacaaaacgactctcaagaagatcatc 13848
 13849 ttattaagggtctgcagctcagtggaacgaaactcacgttaagggttttgggtcatgagattatcaaaaaggatcttc 13928
 13929 acctagatcccttttaattaaaaatgaagttttaaataactctaaagtatatatgagtaaaacttggcttgacagttacca 14008
 14009 atgcttaactcagtgaggcacctatctcagcgatctgtctatttctgttcatccatagttgcctgactccccgtcgctgaga 14088
 14089 taactacgatacggggagggtttaccatctggccccagtgctgcaatgataccgcgagaccacgctcaccggctccagat 14168
 14169 ttatcagcaataaaaccagccagcgggaaggccgagcgcagaagtggtcctgcaactttatccgctccatccagttctat 14248
 14249 taattgttgcgggaagctagagtaagtagttcggcagtttaatagtttgcgcaacgttgttgccattgctgcaggcatcg 14328
 14329 tgggtgcacgctcgctggtttgggtatggcttcatcagctccggttcccaacgatcaaggcgagttacatgatcccccatg 14408
 14409 ctgtgcataaaaggcgttagctcccttcgggtcctccgatcgtgtgcagaagtaagttggccgagtggttatcactcatggt 14488
 14489 tatggcagcactgcataattctcttactgtcatgccatccgtaagatgcttttctgtgactgggtgagtactcaaccaagt 14568
 14569 cattctgagaatagtgatgcggcgacaggttgcctcttggccggtcaacacgggataataaccgcgccacatagcaga 14648
 14649 actttaaaagtgtcatcatctggaacacgttcttcggggcgaaaactctcaaggatcttaccgctgttgagatccagttc 14728
 14729 gatgtaaacctcgtgcacccaactgatcttcagcatctttactttcaccagcgtttctgggtgagcaaaaacaggaa 14808
 14809 ggcaaaatgccgcaaaaagggaataaaggcgacacggaatgttgaatactcatatcttctcttttcaatattattga 14888
 14889 agcatttatcagggttattgtctcatgagcggatcacatattgaatgtatttagaaaaataacaaataggggttccgcg 14968
 14969 cacatttccccgaaaagtgccacctgacgtcgacctgaggttaattataaccggggcccttatatggatccaattctaga 15048
 15049 taatcagactcactata 15065

FIGURE 10-8

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BVDV NADL (inf. clone) -> Genes

DNA sequence 12578 b.p. gtatacgagaat ... ctaacagccccc linear

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1 gtatacgagaattagaaaaggcactcgtatcgtattgggcaattaaaaataataattaggcctagggaacaaatccctc 80
81 tcacgcaaggccgaaaagaggctagccatgcccttagtaggactagcataatgaggggggtagcaacagtggtgagttcg 160
161 ttggatggccttaagccctgagtagcagggtagtcgctcagtggttcgacgccttggataaaggcttcgagatgccacgtgg 240
241 acgagggcatgccccaaagcacatcttaacctgagcgggggtcgcccagggtaaaagcagttttaaccgactgttacgaata 320
321 cagcctgatagggtgctgcagaggccactgtattgctactaaaaatctctgctgtacatggcac ATG GAG TTG 394
1 M E L 3
395 ATC ACA AAT GAA CTT TTA TAC AAA ACA TAC AAA CAA AAA CCC GTC GGG GTG GAG GAA CCT 454
4 I T N E L L Y K T Y K Q K P V G V E E P 23
455 GTT TAT GAT CAG GCA GGT GAT CCC TTA TTT GGT GAA AGG GGA GCA GTC CAC CCT CAA TCG 514
24 V Y D Q A G D P L F G E R G A V H P Q S 43
515 ACG CTA AAG CTC CCA CAC AAG AGA GGG GAA CGC GAT GTT CCA ACC AAC TTG GCA TCC TTA 574
44 T L K L P H K R G E R D V P T N L A S L 63
575 CCA AAA AGA GGT GAC TGC AGG TCG GGT AAT AGC AGA GGA CCT GTG AGC GGG ATC TAC CTG 634
64 P K R G D C R S G N S R G P V S G I Y L 83
635 AAG CCA GGG GCA CTA TTT TAC CAG GAC TAT AAA GGT CCC GTC TAT CAC AGG GCC CCG CTG 694
84 K P G P L F Y Q D Y K G P V Y H R A P L 103
695 GAG CTC TTT GAG GAG GGA TCC ATG TGT GAA ACG ACT AAA CGG ATA GGG AGA GTA ACT GGA 754
104 E L F E E G S M C E T T K R I G R V T G 123
755 AGT GAC GGA AAG CTG TAC CAC ATT TAT GTG TGT ATA GAT GGA TGT ATA ATA AAA AGT 814
124 S D G K L Y H I Y V C I D G C I I I K S 143
815 GCC ACG AGA AGT TAC CAA AGG GTG TTC AGG TGG GTC CAT AAT AGG CTT GAC TGC CCT CTA 874
144 A T R S Y Q R V F R W V H N R L D C P L 163
875 TGG GTC ACA ACT TGC TCA GAC ACG AAA GAA GAG GGA GCA ACA AAA AAG AAA ACA CAG AAA 934
164 W V T T C S D T K E E G A T K K K T Q K 183
935 CCC GAC AGA CTA GAA AGG GGG AAA ATG AAA ATA GAT CCC AAA GAA TCT GAA AAA GAC AGC 994
184 P D R L E R G K M K I V P K E S E K D S 203
995 AAA ACT AAA CCT CCG GAT GCT ACA ATA GTG GTG GAA GGA GTC AAA TAC CAG GTG AGG AAG 1054
204 K T K P P D A T I V V E G V K Y Q V R K 223
1055 AAG GGA AAA ACC AAG AGT AAA AAC ACT CAG GAC GGC TTG TAC CAT AAC AAA AAC AAA CCT 1114
224 K G K T K S K N T Q D G L Y H N K N K P 243
1115 CAG GAA TCA CGC AAG AAA CTG GAA AAA GCA TTG TTG GCG TGG GCA ATA ATA GCT ATA GTT 1174
244 Q E S R K K L E K A L L A W A I I A I V 263
1175 TTG TTT CAA GTT ACA ATG GGA GAA AAC ATA ACA CAG TGG AAC CTA CAA GAT AAT GGG ACG 1234
264 L F Q V T M G E N I T Q W N L Q D N G T 283
1235 GAA GGG ATA CAA CGG GCA ATG TTC CAA AGG GGT GTG AAT AGA AGT TTA CAT GGA ATC TGG 1294
284 E G I Q R A M F Q R G V N R S L H G I W 303
1295 CCA GAG AAA ATC TGT ACT GGT GTC CCT TCC CAT CTA GCC ACC GAT ATA GAA CTA AAA ACA 1354
304 P E K I C T G V P S H L A T D I E L K T 323
1355 ATT CAT GGT ATG ATG GAT GCA AGT GAG AAG ACC AAC TAC ACG TGT TGC AGA CTT CAA CGC 1414
324 I H G M M D A S E K T N Y T C C R L Q R 343
1415 CAT GAG TGG AAC AAG CAT GGT TGG TGC AAC TGG TAC AAT ATT GAA CCC TGG ATT CTA GTC 1474
344 H E W N K H G W C N W Y N I E P W I L V 363
1475 ATG AAT AGA ACC CAA GCC AAT CTC ACT GAG GGA CAA CCA CCA AGG GAG TGC GCA GTC ACT 1534
364 M N R T Q A N L T E G Q P P R E C A V T 383
1535 TGT AGG TAT GAT AGG GCT AGT GAC TTA AAC GTG GTA ACA CAA GCT AGA GAT AGC CCC ACA 1594
384 C R Y D R A S D L N V V T Q A R D S P T 403
1595 CCC TTA ACA GGT TGC AAG AAA GGA AAG AAC TTC TCC TTT GCA GGC ATA TTG ATG CCG GGC 1654
404 P L T G K K G K N F S F A G I L M R G 423
1655 CCC TGC AAC TTT GAA ATA GCT GCA AGT GAT GTA TTA TTC AAA GAA CAT GAA CGC ATT AGT 1714
424 P C N F E I A A S D V L F K E H E R I S 443
1715 ATG TTC CAG GAT ACT ACT CTT TAC CTT GTT GAC GGG TTG ACC AAC TCC TTA GAA GGT GCC 1774
444 M F Q D T T L Y L V D G L T N S L E G A 463

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FIGURE 11-1

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BVDV NADL (inf. clone) -> Gen...

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1775 AGA CAA GGA ACC GCT AAA CTG ACA ACC TGG TTA GGC AAG CAG CTC GGG ATA CTA GGA AAA 1834
464 R Q G T A K L T T W L G K Q L G I L G K 483

1835 AAG TTG GAA AAC AAG AGT AAG ACG TGG TTT GGA GCA TAC GCT GCT TCC CCT TAC TGT GAT 1894
484 K L E N K S K T W F G A Y A A S P Y C D 503

1895 GTC GAT CGC AAA ATT GGC TAC ATA TGG TAT ACA AAA AAT TGC ACC CCT GCC TGC TTA CCC 1954
504 V D R K I G Y I W Y T K N C T P A C L P 523

1955 AAG AAC ACA AAA ATT GTC GGC CCT GGG AAA TTT GAC ACC AAT GCA GAG GAC GGC AAG ATA 2014
524 K N T K I V G P G K F D T N A E D G K I 543

2015 TTA CAT GAG ATG GGG GGT CAC TTG TCG GAG GTA CTA CTA CTT TCT TTA GTG GTG CTG TCC 2074
544 L H E M G G H L S E V L L L S L V V L S 563

2075 GAC TTC GCA CCG GAA ACA GCT AGT GTA ATG TAC CTA ATC CTA CAT TTT TCC ATC CCA CAA 2134
564 D F A P E T A S V M Y L I L H F S I P Q 583

2135 AGT CAC GTT GAT GTA ATG GAT TGT GAT AAG ACC CAG TTG AAC CTC ACA GTG GAG CTG ACA 2194
584 S H V D V M D C D K T Q L N L T V E L T 603

2195 ACA GCT GAA GTA ATA CCA GGG TCG GTC TGG AAT CTA GGC AAA TAT GTA TGT ATA AGA CCA 2254
604 T A E V I P G S V W N L G K Y V C I R P 623

2255 AAT TGG TGG CCT TAT GAG ACA ACT GTA GTG TTG GCA TTT GAA GAG GTG AGC CAG GTG GTG 2314
624 N W W P Y E T T V V L A F E E V S Q V V 643

2315 AAG TTA GTG TTG AGG GCA CTC AGA GAT TTA ACA CGC ATT TGG AAC GCT GCA ACA ACT ACT 2374
644 K L V L R A L R D L T R I W N A A T T T 663

2375 GCT TTT TTA GTA TGC CTT GTT AAG ATA GTC AGG GGC CAG ATG GTA CAG GGC ATT CTG TGG 2434
664 A F L V C L V K I V R G Q M V Q G I L W 683

2435 CTA CTA TTG ATA ACA GGG GTA CAA GGG CAC TTG GAT TGC AAA CCT GAA TTC TCG TAT GCC 2494
684 L L L I T G V Q G H L D C K P E F S Y A 703

2495 ATA GCA AAG GAC GAA AGA ATT GGT CAA CTG GGG GCT GAA GGC CTT ACC ACC ACT TGG AAG 2554
704 I A K D E R I G Q L G A E G L T T T W K 723

2555 GAA TAC TCA CCT GGA ATG AAG CTG GAA GAC ACA ATG GTC ATT GCT TGG TGC GAA GAT GGG 2614
724 E Y S P G M K L E D T M V I A W C E D G 743

2615 AAG TTA ATG TAC CTC CAA AGA TGC ACG AGA GAA ACC AGG TAT CTC GCA ATC TTG CAT ACA 2674
744 K L M Y L Q R C T R E T R Y L A I L H T 763

2675 AGA GCC TTG CCG ACC AGT GTG GTA TTC AAA AAA CTC TTT GAT GGG CGA AAG CAA GAG GAT 2734
764 R A L P T S V V F K K L F D G R K Q E D 783

2735 GTA GTC GAA ATG AAC GAC AAC TTT GAA TTT GGA CTC TGC CCA TGT GAT GCC AAA CCC ATA 2794
784 V V E M N D N F E F G L C P C D A K P I 803

2795 GTA AGA GGG AAG TTC AAT ACA ACG CTG CTG AAC GGA CCG GCC TTC CAG ATG GTA TGC CCC 2854
804 V R K R G T L L N G P A F Q M V C P 823

2855 ATA GGA TGG ACA GGG ACT GTA AGC TGT ACG TCA TTC AAT ATG GAC ACC TTA GCC ACA ACT 2914
824 I G W T G T V S C T S F N M D T L A T T 843

2915 GTG GTA CGG ACA TAT AGA AGG TCT AAA CCA TTC CCT CAT AGG CAA GGC TGT ATC ACC CAA 2974
844 V V R T Y R R S K P F P H R Q G C I T Q 863

2975 AAG AAT CTG GGG GAG GAT CTC CAT AAC TGC ATC CTT GGA GGA AAT TGG ACT TGT GTG CCT 3034
864 K N L G E D L H N C I L G G N W T C V P 883

3035 GGA GAC CAA CTA CTA TAC AAA GGG GGC TCT ATT GAA TCT TGC AAG TGG TGT GGC TAT CAA 3094
884 G D Q L L Y K G G S I E S C K W C G Y Q 903

3095 TTT AAA GAG AGT GAG GGA CTA CCA CAC TAC CCC ATT GGC AAG TGT AAA TTG GAG AAC GAG 3154
904 F K E S E G L P H Y P I G K C K L E N E 923

3155 ACT GGT TAC AGG CTA GTA GAC AGT ACC TCT TGC AAT AGA GAA GGT GTG GCC ATA GTA CCA 3214
924 T G Y R L V D S T S C N R E G V A I V P 943

3215 CAA GGG ACA TTA AAG TGC AAG ATA GGA AAA ACA ACT GTA CAG GTC ATA GCT ATG GAT ACC 3274
944 Q G T L K C K I G K T T V Q V I A M D T 963

3275 AAA CTC GGA CCT ATG CCT TGC AGA CCA TAT GAA ATC ATA TCA AGT GAG GGG CCT GTA GAA 3334
964 K L G P M P C R P Y E I I S S E G P V E 983

3335 AAG ACA GCG TGT ACT TTC AAC TAC ACT AAG ACA TTA AAA AAT AAG TAT TTT GAG CCC AGA 3394
984 K T A C T F N Y T K T L K N K Y F E P R 1003

3395 GAC AGC TAC TTT CAG CAA TAC ATG CTA AAA GGA GAG TAT CAA TAC TGG TTT GAC CTG GAG 3454
1004 D S Y F Q Q Y M L K G E Y Q Y W F D L E 1023

3455 GTG ACT GAC CAT CAC CGG GAT TAC TTC GCT GAG TCC ATA TTA GTG GTG GTA GTA GCC CTC 3514
1024 V T D H H R D Y F A E S I L V V V V A L 1043

FIGURE 11-2

BVDV NADL (inf. clone) -> Ge...

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3515 TTG GGT GGC AGA TAT GTA CTT TGG TTA CTG GTT ACA TAC ATG GTC TTA TCA GAA CAG AAG 3574
1044 L G G R Y V L W L L V T Y M V L S E Q K 1063

3575 GCC TTA GGG ATT CAG TAT GGA TCA GGG GAA GTG GTG ATG ATG GGC AAC TTG CTA ACC CAT 3634
1064 A L G I Q Y G S G E V V M M G N L L T H 1083

3635 AAC AAT ATT GAA GTG GTG ACA TAC TTC TTG CTG CTG TAC CTA CTG CTG AGG GAG GAG AGC 3694
1084 N N I E V V T Y F L L L Y L L L R E E S 1103

3695 GTA AAG AAG TGG GTC TTA CTC TTA TAC CAC ATC TTA GTG GTA CAC CCA ATC AAA TCT GTA 3754
1104 V K K W V L L L Y H I L V V H P I K S V 1123

3755 ATT GTG ATC CTA CTG ATG ATT GGG GAT GTG GTA AAG GCC GAT TCA GGG GGC CAA GAG TAC 3814
1124 I V I L L M I G D V V K A D S G G Q E Y 1143

3815 TTG GGG AAA ATA GAC CTC TGT TTT ACA ACA GTA GTA CTA ATC GTC ATA GGT TTA ATC ATA 3874
1144 L G K I D L C F T T V V L I V I G L I I 1163

3875 GCC AGG CGT GAC CCA ACT ATA GTG CCA CTG GTA ACA ATA ATG GCA GCA CTG AGG GTC ACT 3934
1164 A R R D P T I V P L V T I M A A L R V T 1183

3935 GAA CTG ACC CAC CAG CCT GGA GTT GAC ATC GCT GTG GCG GTC ATG ACT ATA ACC CTA CTG 3994
1184 E L T H E V D I A V A V M T I T L L 1203

3995 ATG GTT AGC TAT GTG ACA GAT TAT TTT AGA TAT AAA AAA TGG TTA CAG TGC ATT CTC AGC 4054
1204 M V S Y V T D Y F R Y K K W L Q C I L S 1223

4055 CTG GTA TCT GCG GTG TTC TTG ATA AGA AGC CTA ATA TAC CTA GGT AGA ATC GAG ATG CCA 4114
1224 L V S A V F L I R S L I Y L G R I E M P 1243

4115 GAG GTA ACT ATC CCA AAC TGG AGA CCA CTA ACT TTA ATA CTA TTA TAT TTG ATC TCA ACA 4174
1244 E V T I P N W R P L T L I L L Y L I S T 1263

4175 ACA ATT GTA ACG AGG TGG AAG GTT GAC GTG GCT GGC CTA TTG TTG CAA TGT GTG CCT ATC 4234
1264 T I V T R W K V D V A G L L L Q C V P I 1283

4235 TTA TTG CTG GTC ACA ACC TTG TGG GCC GAC TTC TTA ACC CTA ATA CTG ATC CTG CCT ACC 4294
1284 L L L V T T L W A D F L T L I L I L P T 1303

4295 TAT GAA TTG GTT AAA TTA TAC TAT CTG AAA ACT GTT AGG ACT GAT ATA GAA AGA AGT TGG 4354
1304 Y E L V A K L Y Y L K T V R T D I E R S W 1323

4355 CTA GGG GGG ATA GAC TAT ACA AGA GTT GAC TCC ATC TAC GAC GTT GAT GAG AGT GGA GAG 4414
1324 L G G I D Y T R V D S I Y D V D E S G E 1343

4415 GGC GTA TAT CTT TTT CCA TCA AGG CAG AAA GCA CAG GGG AAT TTT TCT ATA CTC TTG CCC 4474
1344 G V Y L F P S R Q K A Q G N F S I L L P 1363

4475 CTT ATC AAA GCA ACA CTG ATA AGT TGC GTC AGC AGT AAA TGG CAG CTA ATA TAC ATG AGT 4534
1364 L I K A T L I S C V S S K W Q L I Y M S 1383

4535 TAC TTA ACT TTG GAC TTT ATG TAC TAC ATG CAC AGG AAA GTT ATA GAA GAG ATC TCA GGA 4594
1384 Y L T L D F M Y Y M H R K V I E E I S G 1403

4595 GGT ACC AAC ATA ATA TCC AGG TTA GTG GCA GCA CTC ATA GAG CTG AAC TGG TCC ATG GAA 4654
1404 G T N I I S R L V A A L I E L N W S M E 1423

4655 GAA GAG GAG AGC AAA GGC TTA AAG AAG TTT TAT CTA TTG TCT GGA AGG TTG AGA AAC CTA 4714
1424 E E S K G L K K F L L S G R L R N L 1443

4715 ATA ATA AAA CAT AAG GTA AAG AAT GAG ACC GTG GCT TCT TGG TAC GGG GAG GAG GAA GTC 4774
1444 I I K H K V R N E T V A S W Y G E E E V 1463

4775 TAC GGT ATG CCA AAG ATC ATG ACT ATA ATC AAG GCC AGT ACA CTG AGT AAG AGC AGG CAC 4834
1464 Y G M P K I M T I I K A S T L S K S R H 1483

4835 TGC ATA ATA TGC ACT GTA TGT GAG GGC CGA GAG TGG AAA GGT GGC ACC TGC CCA AAA TGT 4894
1484 C I I C T V C E G R E W K G G T C P K C 1503

4895 GGA CGC CAT GGG AAG CCG ATA ACG TGT GGG ATG TCG CTA GCA GAT TTT GAA GAA AGA CAC 4954
1504 G R H G K P I T C G M S L A D F E E R H 1523

4955 TAT AAA AGA ATC TTT ATA AGG GAA GGC AAC TTT GAG GGT ATG TGC AGC CGA TGC CAG GGA 5014
1524 Y K R I F I R E G N F E G M C S R C Q G 1543

5015 AAG CAT AGG AGG TTT GAA ATG GAC CGG GAA CCT AAG AGT GCC AGA TAC TGT GCT GAG TGT 5074
1544 K H R R F E M D R E P K S A R Y C A E C 1563

5075 AAT AGG CTG CAT CCT GCT GAG GAA GGT GAC TTT TGG GCA GAG TCG AGC ATG TTG GGC CTC 5134
1564 N R L H P A E E G D F W A E S S M L G L 1583

5135 AAA ATC ACC TAC TTT GCG CTG ATG GAT GGA AAG GTG TAT GAT ATC ACA GAG TGG GCT GGA 5194
1584 K I T Y F A L M D G K V Y D I T E W A G 1603

5195 TGC CAG CGT GTG GGA ATC TCC CCA GAT ACC CAC AGA GTC CCT TGT CAC ATC TCA TTT GGT 5254
1604 C Q R V G I S P D T H R V P C H I S F G 1623

FIGURE 11-3

BVDV NADL (inf. clone) -> G. 25/67 4/21/99 5:42:22 PM Page 4

5255 TCA CGG ATG CCT TTC AGG CAG GAA TAC AAT GGC TTT GTA CAA TAT ACC GCT AGG GGG CAA 5314
1624 S R M P F R Q E Y N G F V Q Y T A R G Q 1643

5315 CTA TTT CTG AGA AAC TTG CCC GTA CTG GCA ACT AAA GTA AAA ATG CTC ATG GTA GGC AAC 5374
1644 L F L R N L P V L A T K V K M L M V G N 1663

5375 CTT GGA GAA GAA ATT GGT AAT CTG GAA CAT CTT GGG TGG ATC CTA AGG GGG CCT GCC GTG 5434
1664 L G E E I G N L E H L G W I L R G P A V 1683

5435 TGT AAG AAG ATC ACA GAG CAC GAA AAA TGC CAC ATT AAT ATA CTG GAT AAA CTA ACC GCA 5494
1684 C K K I T E H E K C H I N I L D K L T A 1703

5495 TTT TTC GGG ATC ATG CCA AGG GGG ACT ACA CCC AGA GCC CCG GTG AGG TTC CCT ACG AGC 5554
1704 F F I G P R A P V R F P T S 1723

5555 TTA CTA AAA GTG AGG AGG GGT CTG GAG ACT GCC TGG GCT TAC ACA CAC CAA GGC GGG ATA 5614
1724 L L K V R R G L E T A W A Y T H Q G G I 1743

5615 AGT TCA GTC GAC CAT GTA ACC GCC GGA AAA GAT CTA CTG GTC TGT GAC AGC ATG GGA CGA 5674
1744 S S V D H V T A G K D L L V C D S M G R 1763

5675 ACT AGA GTG GTT TGC CAA AGC AAC AAC AGG TTG ACC GAT GAG ACA GAG TAT GGC GTC AAG 5734
1764 T R V V C Q S N N R L T D E T E Y G V K 1783

5735 ACT GAC TCA GGG TGC CCA GAC GGT GCC AGA TGT TAT GTG TTA AAT CCA GAG GCC GTT AAC 5794
1784 T D S G C P D G A R C Y V L N P E A V N 1803

5795 ATA TCA GGA TCC AAA GGG GCA GTC GTT CAC CTC CAA AAG ACA GGT GGA GAA TTC ACG TGT 5854
1804 I S G S K G A V V H L Q K T G G E F T C 1823

5855 GTC ACC GCA TCA GGC ACA CCG GCT TTC TTC GAC CTA AAA AAC TTG AAA GGA TGG TCA GGC 5914
1824 V T A S G T P A F F D L K N L K G W S G 1843

5915 TTG CCT ATA TTT GAA GCC TCC AGC GGG AGG GTG GTT GGC AGA GTC AAA GTA GGG AAG AAT 5974
1844 L P I F E A S S G R V V G R V K V G K N 1863

5975 GAA GAG TCT AAA CCT ACA AAA ATA ATG AGT GGA ATC CAG ACC GTC TCA AAA AAC AGA GCA 6034
1864 E E S K P T K I M S G I Q T V S K N R A 1883

6035 GAC CTG ACC GAG ATG GTC AAG AAG ATA ACC AGC ATG AAC AGG GGA GAC TTC AAG CAG ATT 6094
1884 D L T E M V K K I T S M N R G D F K Q I 1903

6095 ACT TTG GCA ACA GGG GCA GGC AAA ACC ACA GAA CTC CCA AAA GCA GTT ATA GAG GAG ATA 6154
1904 T L A T G A G K T T E L P K A V I E E I 1923

6155 GGA AGA CAC AAG AGA GTA TTA GTT CTT ATA CCA TTA AGG GCA GCG GCA GAG TCA GTC TAC 6214
1924 G R H K R V L V L I P L R A A A E S V Y 1943

6215 CAG TAT ATG AGA TTG AAA CAC CCA AGC ATC TCT TTT AAC CTA AGG ATA GGG GAC ATG AAA 6274
1944 Q Y M R L K H P S I S F N L R I G D M K 1963

6275 GAG GGG GAC ATG GCA ACC GGG ATA ACC TAT GCA TCA TAC GGG TAC TTC TGC CAA ATG CCT 6334
1964 E G D M A T G I T Y A S Y G Y F C Q M P 1983

6335 CAA CCA AAG CTC AGA GCT GCT ATG GTA GAA TAC TCA TAC ATA TTC TTA GAT GAA TAC CAT 6394
1984 Q P K L R A A M V E Y S Y I F L D E Y H 2003

6395 TGT GCC ACT CCT GAA CAA CTG GCA ATT ATC GGG AAG ATC CAC AGA TTT TCA GAG AGT ATA 6454
2004 C A T P E Q L A I I G K I H R F S E S I 2023

6455 AGG GTT GTC GCC ATG ACT GCC ACG CCA GCA GGG TCG GTG ACC ACA ACA GGT CAA AAG CAC 6514
2024 R V V A M T A T P A G S V T T T G Q K H 2043

6515 CCA ATA GAG GAA TTC ATA GCC CCC GAG GTA ATG AAA GGG GAG GAT CTT GGT AGT CAG TTC 6574
2044 P I E E F I A P E V M K G E D L G S Q F 2063

6575 CTT GAT ATA GCA GGG TTA AAA ATA CCA GTG GAT GAG ATG AAA GGC AAT ATG TTG GTT TTT 6634
2064 L D I A G L K I P V D E M K G N M L V F 2083

6635 GTA CCA ACG AGA AAC ATG GCA GTA GAG GTA GCA AAG AAG CTA AAA GCT AAG GGC TAT AAC 6694
2084 V P T R N M A V E V A K K L K A K G Y N 2103

6695 TCT GGA TAC TAT TAC AGT GGA GAG GAT CCA GCC AAT CTG AGA GTT GTG ACA TCA CAA TCC 6754
2104 S G Y Y Y S G E D P A N L R V V T S Q S 2123

6755 CCC TAT GTA ATC GTG GCT ACA AAT GCT ATT GAA TCA GGA GTG ACA CTA CCA GAT TTG GAC 6814
2124 P Y V I V A T N A I E S G V T L P D L D 2143

6815 ACG GTT ATA GAC ACG GGG TTG AAA TGT GAA AAG AGG GTG AGG GTA TCA TCA AAG ATA CCC 6874
2144 T V I D T G L K K C E K R V R V S S K I P 2163

6875 TTC ATC GTA ACA GGC CTT AAG AGG ATG GCC GTG ACT GTG GGT GAG CAG GCG CAG CGT AGG 6934
2164 F I V T G L K R M A V T V G E Q A Q R R 2183

6935 GGC AGA GTA GGT AGA GTG AAA CCC GGG AGG TAT TAT AGG AGC CAG GAA ACA GCA ACA GGG 6994
2184 G R V G R V K P G R Y Y R S Q E T A T G 2203

FIGURE 11-4

BVDV NADL (inf. clone) -> Gc

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6995 TCA AAG GAC TAC CAC TAT GAC CTC TTG CAG GCA CAA AGA TAC GGG ATT GAG GAT GGA ATC 7054
2204 S K D Y H Y D L L Q A Q R Y G I E D G I 2223

7055 AAC GTG ACG AAA TCC TTT AGG GAG ATG AAT TAC GAT TGG AGC CTA TAC GAG GAG GAC AGC 7114
2224 N V T K S F R E M N Y D W S L Y E E D S 2243

7115 CTA CTA ATA ACC CAG CTG GAA ATA CTA AAT AAT CTA CTC ATC TCA GAA GAC TTG CCA GCC 7174
2244 L L I T Q L E I L N N L L I S E D L P A 2263

7175 GCT GTT AAG AAC ATA ATG GCC AGG ACT GAT CAC CCA GAG CCA ATC CAA CTT GCA TAC AAC 7234
2264 A V K N I M A R T D H P E P I Q L A Y N 2283

7235 AGC TAT GAA GTC CAG GTC CCG GTC CTG TTC CCA AAA ATA AGG AAT GGA GAA GTC ACA GAC 7294
2284 S Y E V Q V L F V K I R N G E V T D 2303

7295 ACC TAC GAA AAT TAC TCG TTT CTA AAT GCC AGA AAG TTA GGG GAG GAT GTG CCC GTG TAT 7354
2304 T Y E N Y S F L N A R K L G E D V P V Y 2323

7355 ATC TAC GCT ACT GAA GAT GAG GAT CTG GCA GTT GAC CTC TTA GGG CTA GAC TGG CCT GAT 7414
2324 I Y A T E D E D L A V D L L G L D W P D 2343

7415 CCT GGG AAC CAG CAG GTA GTG GAG ACT GGT AAA GCA CTG AAG CAA GTG ACC GGG TTG TCC 7474
2344 P G N Q Q V V E T G K A L K Q V T G L S 2363

7475 TCG GCT GAA AAT GCC CTA CTA GTG GCT TTA TTT GGG TAT GTG GGT TAC CAG GCT CTC TCA 7534
2364 S A E N A L L V A L F G Y V G Y Q A L S 2383

7535 AAG AGG CAT GTC CCA ATG ATA ACA GAC ATA TAT ACC ATC GAG GAC CAG AGA CTA GAA GAC 7594
2384 K R H V P M I T D I Y T I E D Q R L E D 2403

7595 ACC ACC CAC CTC CAG TAT GCA CCC AAC GCC ATA AAA ACC GAT GGG ACA GAG ACT GAA CTG 7654
2404 T T H L Q Y A P N A I K T D G T E T E L 2423

7655 AAA GAA CTG GCG TCG GGT GAC GTG GAA AAA ATC ATG GGA GCC ATT TCA GAT TAT GCA GCT 7714
2424 K E L A S G D V E K I M G A I S D Y A A 2443

7715 GGG GGA CTG GAG TTT GTT AAA TCC CAA GCA GAA AAG ATA AAA ACA GCT CCT TTG TTT AAA 7774
2444 G G L E F V K S Q A E K I K T A P L F K 2463

7775 GAA AAC GCA GAA GCC GCA AAA GGG TAT GTC CAA AAA TTC ATT GAC TCA TTA ATT GAA AAT 7834
2464 E N A E A A K G Y V Q K F I D S L I E N 2483

7835 AAA GAA GAA ATA ATC AGA TAT GGT TTG TGG GGA ACA CAC ACA GCA CTA TAC AAA AGC ATA 7894
2484 K E E I I R Y G L W G T H T A L Y K S I 2503

7895 GCT GCA AGA CTG GGG CAT GAA ACA GCG TTT GCC ACA CTA GTG TTA AAG TGG CTA GCT TTT 7954
2504 A A R L G H E T A F A T L V L K W L A F 2523

7955 GGA GGG GAA TCA GTG TCA GAC CAC GTC AAG CAG GCG GCA GTT GAT TTA GTG GTC TAT TAT 8014
2524 G G E S V S D H V K Q A A V D L V V Y Y 2543

8015 GTG ATG AAT AAG CCT TCC TTC CCA GGT GAC TCC GAG ACA CAG CAA GAA GGG AGG CGA TTC 8074
2544 V M N K P S F P G D S E T Q Q E G R R F 2563

8075 GTC GCA AGC CTG TTC ATC TCC GCA CTG GCA ACC TAC ACA TAC AAA ACT TGG AAT TAC CAC 8134
2564 V A S L F I S A L A T Y T Y K T W N Y H 2583

8135 AAT CTC TCT AAA GTG GTG GAA CCA GCC CTG GCT TAC CTC CCC TAT GCT ACC AGC GCA TTA 8194
2584 N L S K V V E P A L A Y L P Y A T S A L 2603

8195 AAA ATG TTC ACC CCA ACG CGG CTG GAG AGC GTG GTG ATA CTG AGC ACC ACG ATA TAT AAA 8254
2604 K M F T P T R L E S V V I L S T T I Y K 2623

8255 ACA TAC CTC TCT ATA AGG AAG GGG AAG AGT GAT GGA TTG CTG GGT ACG GGG ATA AGT GCA 8314
2624 T Y L S I R K G K S D G L L G T G I S A 2643

8315 GCC ATG GAA ATC CTG TCA CAA AAC CCA GTA TCG GTA GGT ATA TCT GTG ATG TTG GGG GTA 8374
2644 A M E I L S Q N P V S V G I S V M L G V 2663

8375 GGG GCA ATC GCT GCG CAC AAC GCT ATT GAG TCC AGT GAA CAG AAA AGG ACC CTA CTT ATG 8434
2664 G A I A A H N A I E S S E Q K R T L L M 2683

8435 AAG GTG TTT GTA AAG AAC TTC TTG GAT CAG GCT GCA ACA GAT GAG CTG GTA AAA GAA AAC 8494
2684 K V F V K N F L D Q A A T D E L V K E N 2703

8495 CCA GAA AAA ATT ATA ATG GCC TTA TTT GAA GCA GTC CAG ACA ATT GGT AAC CCC CTG AGA 8554
2704 P E K I I M A L F E A V Q T I G N P L R 2723

8555 CTA ATA TAC CAC CTG TAT GGG GTT TAC TAC AAA GGT TGG GAG GCC AAG GAA CTA TCT GAG 8614
2724 L I Y H L Y G V Y Y K G W E A K E L S E 2743

8615 AGG ACA GCA GGC AGA AAC TTA TTC ACA TTG ATA ATG TTT GAA GCC TTC GAG TTA TTA GGG 8674
2744 R T A G R N L F T L I M F E A F E L L G 2763

8675 ATG GAC TCA CAA GGG AAA ATA AGG AAC CTG TCC GGA AAT TAC ATT TTG GAT TTG ATA TAC 8734
2764 M D S Q G K I R N L S G N Y I L D L I Y 2783

FIGURE 11-5

BVDV NADL (inf. clone) -> Gc

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8735 GGC CTA CAC AAG CAA ATC AAC AGA GGG CTG AAG AAA ATG GTA CTG GGG TGG GCC CCT GCA 8794
2784 G L H K Q I N R G L K K M V L G W A P A 2803

8795 CCC TTT AGT TGT GAC TGG ACC CCT AGT GAC GAG AGG ATC AGA TTG CCA ACA GAC AAC TAT 8854
2804 P F S C D W T P S D E R I R L P T D N Y 2823

8855 TTG AGG GTA GAA ACC AGG TGC CCA TGT GGC TAT GAG ATG AAA GCT TTC AAA AAT GTA GGT 8914
2824 L R V E T R C P C G Y E M K A F K N V G 2843

8915 GGC AAA CTT ACC AAA GTG GAG GAG AGC GGG CCT TTC CTA TGT AGA AAC AGA CCT GGT AGG 8974
2844 G K L T K V E E S G P F L C R N R P G R 2863

8975 GGA CCA GTC AAC TAC AGA GTC ACC AAG TAT TAC GAT GAC AAC CTC AGA GAG ATA AAA CCA 9034
2864 G P V N Y R V T K Y Y D D N L R E I K P 2883

9035 GTA GCA AAG TTG GAA GGA CAG GTA GAG CAC TAC TAC AAA GGG GTC ACA GCA AAA ATT GAC 9094
2884 V A K L E G Q V E H Y Y K G V T A K I D 2903

9095 TAC AGT AAA GGA AAA ATG CTC TTG GCC ACT GAC AAG TGG GAG GTG GAA CAT GGT GTC ATA 9154
2904 Y S K K M L L A T D K W E V E H G V I 2923

9155 ACC AGG TTA GCT AAG AGA TAT ACT GGG GTC GGG TTC AAT GGT GCA TAC TTA GGT GAC GAG 9214
2924 T R L A K R Y T G V G F N G A Y L G D E 2943

9215 CCC AAT CAC CGT GCT CTA GTG GAG AGG GAC TGT GCA ACT ATA ACC AAA AAC ACA GTA CAG 9274
2944 P N H R A L V E R D C A T I T K N T V Q 2963

9275 TTT CTA AAA ATG AAG AAG GGG TGT GCG TTC ACC TAT GAC CTG ACC ATC TCC AAT CTG ACC 9334
2964 F L K M K K G C A F T Y D L T I S N L T 2983

9335 AGG CTC ATC GAA CTA GTA CAC AGG AAC AAT CTT GAA GAG AAG GAA ATA CCC ACC GCT ACG 9394
2984 R L I E L V H R N N L E E K E I P T A T 3003

9395 GTC ACC ACA TGG CTA GCT TAC ACC TTC GTG AAT GAA GAC GTA GGG ACT ATA AAA CCA GTA 9454
3004 V T T W L A Y T F V N E D V G T I K P V 3023

9455 CTA GGA GAG AGA GTA ATC CCC GAC CCT GTA GTT GAT ATC AAT TTA CAA CCA GAG GTG CAA 9514
3024 L G E R V I P D P V D I N L Q P E V Q 3043

9515 GTG GAC ACG TCA GAG GTT GGG ATC ACA ATA ATT GGA AGG GAA ACC CTG ATG ACA ACG GGA 9574
3044 V D T S E V G I T I I G R E T L M T T G 3063

9575 GTG ACA CCT GTC TTG GAA AAA GTA GAG CCT GAC GCC AGC GAC AAC CAA AAC TCG GTG AAG 9634
3064 V T P V L E K V E P D A S D N Q N S V K 3083

9635 ATC GGG TTG GAT GAG GGT AAT TAC CCA GGG CCT GGA ATA CAG ACA CAT ACA CTA ACA GAA 9694
3084 I G L D E G N Y P G P G I Q T H T L T E 3103

9695 GAA ATA CAC AAC AGG GAT GCG AGG CCC TTC ATC ATG ATC CTG GGC TCA AGG AAT TCC ATA 9754
3104 E I H N R D A R P F I M I L G S R N S I 3123

9755 TCA AAT AGG GCA AAG ACT GCT AGA AAT ATA AAT CTG TAC ACA GGA AAT GAC CCC AGG GAA 9814
3124 S N R A K T A R N I N L Y T G N D P R E 3143

9815 ATA CGA GAC TTG ATG GCT GCA GGG CGC ATG TTA GTA GTA GCA CTG AGG GAT GTC GAC CCT 9874
3144 I R D L M A A G R M L V V A L R D V D P 3163

9875 GAG CTG TCT GAA ATG GTC GAT TTC AAG GGG ACT TTT TTA GAT AGG GAG GCC CTG GAG GCT 9934
3164 E L S E M V D F K G T F L D R E A L E A 3183

9935 CTA AGT CTC GGG CAA CCT AAA CCG AAG CAG GTT ACC AAG GAA GCT GTT AGG AAT TTG ATA 9994
3184 L S L G Q P K P K Q V T K E A V R N L I 3203

9995 GAA CAG AAA AAA GAT GTG GAG ATC CCT AAC TGG TTT GCA TCA GAT GAC CCA GTA TTT CTG 10054
3204 E Q K K D V E I P N W F A S D D P V F L 3223

10055 GAA GTG GCC TTA AAA AAT GAT AAG TAC TAC TTA GTA GGA GAT GTT GGA GAG CTA AAA GAT 10114
3224 E V A L K N D K Y Y L V G D V G E L K D 3243

10115 CAA GCT AAA GCA CTT GGG GCC ACG GAT CAG ACA AGA ATT ATA AAG GAG GTA GGC TCA AGG 10174
3244 Q A K A L G A T D Q T R I I K E V G S R 3263

10175 ACG TAT GCC ATG AAG CTA TCT AGC TGG TTC CTC AAG GCA TCA AAC AAA CAG ATG AGT TTA 10234
3264 T Y A M K L S S W F L K A S N K Q M S L 3283

10235 ACT CCA CTG TTT GAG GAA TTG TTG CTA CCG TGC CCA CCT GCA ACT AAG AGC AAT AAG GGG 10294
3284 T P L F E E L L L R C P P A T K S N K G 3303

10295 CAC ATG GCA TCA GCT TAC CAA TTG GCA CAG GGT AAC TGG GAG CCC CTC GGT TGC GGG GTG 10354
3304 H M A S A Y Q L A Q G N W E P L G C G V 3323

10355 CAC CTA GGT ACA ATA CCA GCC AGA AGG GTG AAG ATA CAC CCA TAT GAA GCT TAC CTG AAG 10414
3324 H L G T I P A R R V K I H P Y E A Y L K 3343

10415 TTG AAA GAT TTC ATA GAA GAA GAA GAG AAG AAA CCT AGG GTT AAG GAT ACA GTA ATA AGA 10474
3344 L K D F I E E E E K K P R V K D T V I R 3363

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FIGURE 11-6

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10475 GAG CAC AAC AAA TGG A AAA ATA AGG TTT CAA GGA AAC CTC AAC ACC AAG AAA 10534
3364 E H N K W K I R F Q G N L N T K K 3383

10535 ATG CTC AAC CCG GGG AAA CTA TCT GAA CAG TTG GAC AGG GAG GGG CGC AAG AGG AAC ATC 10594
3384 M L N P G K L S E Q L D R E G R K R N I 3403

10595 TAC AAC CAC CAG ATT GGT ACT ATA ATG TCA AGT GCA GGC ATA AGG CTG GAG AAA TTG CCA 10654
3404 Y N H Q I G T I M S S A G I R L E K L P 3423

10655 ATA GTG AGG GCC CAA ACC GAC ACC AAA ACC TTT CAT GAG GCA ATA AGA GAT AAG ATA GAC 10714
3424 I V R A Q T D T K T F H E A I R D K I D 3443

10715 AAG AGT GAA AAC CCG CAA AAT CCA GAA TTG CAC AAC AAA TTG TTG GAG ATT TTC CAC ACG 10774
3444 K S E N R Q N P E L H N K L L E I F H T 3463

10775 ATA GCC CAA CCC ACC CTG AAA CAC ACC TAC GGT GAG GTG ACG TGG GAG CAA CTT GAG GCG 10834
3464 I A Q P T L K H T Y G E V T W E Q L E A 3483

10835 GGG ATA AAT AGA AAG GGG GCA GCA GGC TTC CTG GAG AAG AAG AAC ATC GGA GAA GTA TTG 10894
3484 G I N R K G A A G F L E K K N I G E V L 3503

10895 GAT TCA GAA AAG CAC CTG GTA GAA CAA TTG GTC AGG GAT CTG AAG GCC GGG AGA AAG ATA 10954
3504 D S E K H L V E Q L V R D L K A G R K I 3523

10955 AAA TAT TAT GAA ACT GCA ATA CCA AAA AAT GAG AAG AGA GAT GTC AGT GAT GAC TGG CAG 11014
3524 K Y Y E T A I P K N E K R D V S D D W Q 3543

11015 GCA GGG GAC CTG GTG GTT GAG AAG AGG CCA AGA GTT ATC CAA TAC CCT GAA GCC AAG ACA 11074
3544 A G D L V V E K R P R V I Q Y P E A K T 3563

11075 AGG CTA GCC ATC ACT AAG GTC ATG TAT AAC TGG GTG AAA CAG CAG CCC GTT GTG ATT CCA 11134
3564 R L A I T K V M Y N W V K Q Q P V V I P 3583

11135 GGA TAT GAA GGA AAG ACC CCC TTG TTC AAC ATC TTT GAT AAA GTG AGA AAG GAA TGG GAC 11194
3584 G Y E G K T P L F N I F D K V R K E W D 3603

11195 TCG TTC AAT GAG CCA GTG GCC GTA AGT TTT GAC ACC AAA GCC TGG GAC ACT CAA GTG ACT 11254
3604 S F N E P V A V S F D T K A W D T Q V T 3623

11255 AGT AAG GAT CTG CAA CTT ATT GGA GAA ATC CAG AAA TAT TAC TAT AAG AAG GAG TGG CAC 11314
3624 S K D L L I G E I Q K Y Y K K E W H 3643

11315 AAG TTC ATT GAC ACC ATC ACC GAC CAC ATG ACA GAA GTA CCA GTT ATA ACA GCA GAT GGT 11374
3644 K F I D T I T D H M T E V P V I T A D G 3663

11375 GAA GTA TAT ATA AGA AAT GGG CAG AGA GGG AGC GGC CAG CCA GAC ACA AGT GCT GGC AAC 11434
3664 E V Y I R N G Q R G S G Q P D T S A G N 3683

11435 AGC ATG TTA AAT GTC CTG ACA ATG ATG TAC GGC TTC TGC GAA AGC ACA GGG GTA CCG TAC 11494
3684 S M L N V L T M M Y G F C E S T G V P Y 3703

11495 AAG AGT TTC AAC AGG GTG GCA AGG ATC CAC GTC TGT GGG GAT GAT GGC TTC TTA ATA ACT 11554
3704 K S F N R V A R I H V C G D D G F L I T 3723

11555 GAA AAA GGG TTA GGG CTG AAA TTT GCT AAC AAA GGG ATG CAG ATT CTT CAT GAA GCA GGC 11614
3724 E K G L G L K F A N K G M Q I L H E A G 3743

11615 AAA CCT CAG AAG ATA ACG GAA GGG GAA AAG ATG AAA GTT GCC TAT AGA TTT GAG GAT ATA 11674
3744 K P Q K I T E G E K M K V A Y R F E D I 3763

11675 GAG TTC TGT TCT CAT ACC CCA GTC CCT GTT AGG TGG TCC GAC AAC ACC AGT AGT CAC ATG 11734
3764 E F C S H T P V P V R W S D N T S S H M 3783

11735 GCC GGG AGA GAC ACC GCT GTG ATA CTA TCA AAG ATG GCA ACA AGA TTG GAT TCA AGT GGA 11794
3784 A G R D T A V I L S K M A T R L D S S G 3803

11795 GAG AGG GGT ACC ACA GCA TAT GAA AAA GCG GTA GCC TTC AGT TTC TTG CTG ATG TAT TCC 11854
3804 E R G T T A Y E K A V A F S F L L M Y S 3823

11855 TGG AAC CCG CTT GTT AGG AGG ATT TGC CTG TTG GTC CTT TCG CAA CAG CCA GAG ACA GAC 11914
3824 W N P L V R R I C L L V L S Q Q P E T D 3843

11915 CCA TCA AAA CAT GCC ACT TAT TAT TAC AAA GGT GAT CCA ATA GGG GCC TAT AAA GAT GTA 11974
3844 P S K H A T Y Y Y K G D P I G A Y K D V 3863

11975 ATA GGT CGG AAT CTA AGT GAA CAG AGA ACA GGC TTT GAG AAA TTG GCA AAT CTA AAC 12034
3864 I G R N L S E L K R T G F E K L A N L N 3883

12035 CTA AGC CTG TCC ACG TTG GGG ATC TGG ACT AAG CAC ACA AGC AAA AGA ATA ATT CAG GAC 12094
3884 L S L S T L G I W T K H T S K R I I Q D 3903

12095 TGT GTT GCC ATT GGG AAA GAA GAG GGC AAC TGG CTA GTT AAC GCC GAC AGG CTG ATA TCC 12154
3904 C V A I G K E E G N W L V N A D R L I S 3923

12155 AGC AAA ACT GGC CAC TTA TAC ATA CCT GAT AAA GGC TTT ACA TTA CAA GGA AAG CAT TAT 12214
3924 S K T G H L Y I P D K G F T L Q G K H Y 3943

FIGURE 11-7

BVDV NADL (inf. clone) -> G...

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12215 GAG CAA CTG CAG CTA AGA ACA GAG ACA AAC CCG GTC ATG GGG GTT GGG ACT GAG AGA TAC 12274
3944 E Q L Q L R T E T N P V M G V G T E R Y 3963

12275 AAG TTA GGT CCC ATA GTC AAT CTG CTG CTG AGA AGG TTG AAA ATT CTG CTC ATG ACG GCC 12334
3964 K L G P I V N L L L R R L K I L L M T A 3983

12335 GTC GGC GTC AGC AGC TGA gacaaaatgtatatattgtaataaattaatccatgtacatagtgatatataaatat 12408
3984 V G V S S * 3989

12409 agttgggaccgtccacctaagaagacgacacgccccaacacgcacagctaacagtagtcaagattatctacctaagat 12488

12489 aacactacatttaatgcacacagcactttagctgtatgaggatacgcccgacgtctatagttggactaggggaagacctct 12568

12569 aacagccccc 12578
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FIGURE 11-8

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BVDV NADL cIns- (inf. clone) -> Genes

DNA sequence 12308 b.p. gtatacagagaat ... ctaacagccccc linear

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1  gtatacagagaattagaaaaggcactcgtatcgtattgggcaattaaaaataataattaggcctaggggaacaaatccctc 80
81  tcagcgaaggccgaaaagaggctagccatgcccttagtaggactagcataatgagggggtagcaacagtggtgagttcg 160
161  ttgtagggccttaagccctgagtagcagggtagtcgtcagtggttcgacgccttggataaaggctctcgagatgccacgtgg 240
241  acgaggggcatgcccaagcacatcttaacctgagcgggggtcgcccaggtaaaagcagttttaaccgactgttacgaata 320
321  cagccctgataggggtgctgcagagggccactgtattgctactaaaaatctctgctgtacatggcac ATG GAG TTG 394
1  M E L 3
395  ATC ACA AAT GAA CTT TTA TAC AAA ACA TAC AAA CAA AAA CCC GTC GGG GTG GAG GAA CCT 454
4  I T N E L L Y K T Y K Q K P V G V E E P 23
455  GTT TAT GAT CAG GCA GGT GAT CCC TTA TTT GGT GAA AGG GGA GCA GTC CAC CCT CAA TCG 514
24  V Y D Q A G D P L F G E R G A V H P Q S 43
515  ACG CTA AAG CTC CCA CAC AAG AGA GGG GAA CGC GAT GTT CCA ACC AAC TTG GCA TCC TTA 574
44  T L K L P H K R G E R D V P T N L A S L 63
575  CCA AAA AGA GGT GAC TGC AGG TCG GGT AAT AGC AGA GGA CCT GTG AGC GGG ATC TAC CTG 634
64  P K R G D C R S G N S R G P V S G I Y L 83
635  AAG CCA GGG CCA CTA TTT TAC CAG GAC TAT AAA GGT CCC GTC TAT CAC AGG GCC CCG CTG 694
84  K P G P L F Y Q D Y K G P V Y H R A P L 103
695  GAG CTC TTT GAG GAG GGA TCC ATG TGT GAA ACG ACT AAA CGG ATA GGG AGA GTA ACT GGA 754
104  E L F E E G S M C E T T K R I G R V T G 123
755  AGT GAC GGA AAG CTG TAC CAC ATT TAT GTG TGT ATA GAT GGA TGT ATA ATA AAA AGT 814
124  S D G K L Y H I Y V C I D G C I I I K S 143
815  GCC ACG AGA AGT TAC CAA AGG GTG TTC AGG TGG GTC CAT AAT AGG CTT GAC TGC CCT CTA 874
144  A T R S Y Q R V F R W V H N R L D C P L 163
875  TGG GTC ACA ACT TGC TCA GAC ACG AAA GAA GAG GGA GCA ACA AAA AAG AAA ACA CAG AAA 934
164  W V T T C S D T K E E G A T K K K T Q K 183
935  CCC GAC AGA CTA GAA AGG GGG AAA ATG AAA ATA GTG CCC AAA GAA TCT GAA AAA GAC AGC 994
184  P D R L E R G K M K I V P K E S E K D S 203
995  AAA ACT AAA CCT CCG GAT GCT ACA ATA GTG GTG GAA GGA GTC AAA TAC CAG GTG AGG AAG 1054
204  K T K P P D A T I V V E G V K Y Q V R K 223
1055  AAG GGA AAA ACC AAG AGT AAA AAC ACT CAG GAC GGC TTG TAC CAT AAC AAA AAC AAA CCT 1114
224  K G K T K S K N T Q D G L Y H N K N K P 243
1115  CAG GAA TCA CGC AAG AAA CTG GAA AAA GCA TTG TTG GCG TGG GCA ATA ATA GCT ATA GTT 1174
244  Q E S R K K L E K A L A W A I I A I V 263
1175  TTG TTT CAA GTT ACA ATG GGA GAA AAC ATA ACA CAG TGG AAC CTA CAA GAT AAT GGG ACG 1234
264  L F Q V T M G E N I T Q W N L Q D N G T 283
1235  GAA GGG ATA CAA CGG GCA ATG TTC CAA AGG GGT GTG AAT AGA AGT TTA CAT GGA ATC TGG 1294
284  E G I Q R A M F Q R G V N R S L H G I W 303
1295  CCA GAG AAA ATC TGT ACT GGT GTC CCT TCC CAT CTA GCC ACC GAT ATA GAA CTA AAA ACA 1354
304  P E K I C T G V P S H L A T D I E L K T 323
1355  ATT CAT GGT ATG ATG GAT GCA AGT GAG AAG ACC AAC TAC ACG TGT TGC AGA CTT CAA CGC 1414
324  I H G M M D A S E K T N Y T C C R L Q R 343
1415  CAT GAG TGG AAC AAG CAT GGT TGG TGC AAC TGG TAC AAT ATT GAA CCC TGG ATT CTA GTC 1474
344  H E W N K H G W C N W Y N I E P W I L V 363
1475  ATG AAT AGA ACC CAA GCC AAT CTC ACT GAG GGA CAA CCA CCA AGG GAG TGC GCA GTC ACT 1534
364  M N R T Q A N L T E G Q P P R E C A V T 383
1535  TGT AGG TAT GAT AGG GCT AGT GAC TTA AAC GTG GTA ACA CAA GCT AGA GAT AGC CCC ACA 1594
384  C R Y D R A S D L N V V T Q A R D S P T 403
1595  CCC TTA ACA GGT TGC AAG AAA GGA AAG AAC TTC TCC TTT GCA GGC ATA TTG ATG CGG GGC 1654
404  P L T G C K K G K N F S F A G I L M R G 423
1655  CCC TGC AAC TTT GAA ATA GCT GCA AGT GAT GTA TTA TTC AAA GAA CAT GAA CGC ATT AGT 1714
424  P C N F E I A A S D V L F K E H E R I S 443
1715  ATG TTC CAG GAT ACT ACT CTT TAC CTT GTT GAC GGG TTG ACC AAC TCC TTA GAA GGT GCC 1774
444  M F Q D T T L Y L V D G L T N S L E G A 463

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FIGURE 12-1

BVDV NADL clns- (inf. clone)		Genes		31/67		4/21/99	5:45:24 PM	Page 2
1775	AGA CAA GGA ACC GCT AAA CTG ACA ACC TGG TTA GGC AAG CAG CTC GGG ATA CTA GGA AAA	1834						
464	R Q G T A K L T T W L G K Q L G I L G K	483						
1835	AAG TTG GAA AAC AAG AGT AAG ACG TGG TTT GGA GCA TAC GCT GCT TCC CCT TAC TGT GAT	1894						
484	K L E N K S K T W F G A Y A A S P Y C D	503						
1895	GTC GAT CGC AAA ATT GGC TAC ATA TGG TAT ACA AAA AAT TGC ACC CCT GCC TGC TTA CCC	1954						
504	V D R K I G Y I W Y T K N C T P A C L P	523						
1955	AAG AAC ACA AAA ATT GTC GGC CCT GGG AAA TTT GAC ACC AAT GCA GAG GAC GGC AAG ATA	2014						
524	K N T K I V G P G K F D T N A E D G K I	543						
2015	TTA CAT GAG ATG GGG GGT CAC TTG TCG GAG GTA CTA CTA CTT TCT TTA GTG GTG CTG TCC	2074						
544	L H E M G G H L S E V L L L S L V V L S	563						
2075	GAC TTC GCA CCG GAA ACA GCT AGT GTA ATG TAC CTA ATC CTA CAT TTT TCC ATC CCA CAA	2134						
564	D F A P E T A S V M Y L I L H F S I P Q	583						
2135	AGT CAC GTT GAT GTA ATG GAT TGT GAT AAG ACC CAG TTG AAC CTC ACA GTG GAG CTG ACA	2194						
584	S H V D V M D C T K A Q L N L T V E L T	603						
2195	ACA GCT GAA GTA ATA CCA GGG TCG GTC TGG AAT CTA GGC AAA TAT GTA TGT ATA AGA CCA	2254						
604	T A E V I P G S V W N L G K Y V C I R P	623						
2255	AAT TGG TGG CCT TAT GAG ACA ACT GTA GTG TTG GCA TTT GAA GAG GTG AGC CAG GTG GTG	2314						
624	N W W P Y E T T V V L A F E E V S Q V V	643						
2315	AAG TTA GTG TTG AGG GCA CTC AGA GAT TTA ACA CGC ATT TGG AAC GCT GCA ACA ACT ACT	2374						
644	K L V L R A L R D L T R I W N A A T T T	663						
2375	GCT TTT TTA GTA TGC CTT GTT AAG ATA GTC AAG GGC CAG ATG GTA CAG GGC ATT CTG TGG	2434						
664	A F L V C L V K I V R G Q M V Q G I L W	683						
2435	CTA CTA TTG ATA ACA GGG GTA CAA GGG CAC TTG GAT TGC AAA CCT GAA TTC TCG TAT GCC	2494						
684	L L L I T G V Q G H L D C K P E F S Y A	703						
2495	ATA GCA AAG GAC GAA AGA ATT GGT CAA CTG GGG GCT GAA GGC CTT ACC ACC ACT TGG AAG	2554						
704	I A K G D E R I G Q L G A E G L T T T W K	723						
2555	GAA TAC TCA CCT GGA ATG AAG CTG GAA GAC ACA ATG GTC ATT GCT TGG TGC GAA GAT GGG	2614						
724	E Y S P G M K L E D T M V I A W C E D G	743						
2615	AAG TTA ATG TAC CTC CAA AGA TGC ACG AGA GAA ACC AGG TAT CTC GCA ATC TTG CAT ACA	2674						
744	K L M Y L Q R C T R E T R Y L A I L H T	763						
2675	AGA GCC TTG CCG ACC AGT GTG GTA TTC AAA AAA CTC TTT GAT GGG CGA AAG CAA GAG GAT	2734						
764	R A L P T S V V F K K L F D G R K Q E D	783						
2735	GTA GTC GAA ATG AAC GAC AAC TTT GAA TTT GGA CTC TGC CCA TGT GAT GCC AAA CCC ATA	2794						
784	V V E M N D N F E F G L C P C D A K P I	803						
2795	GTA AGA GGG AAG TTC AAT ACA ACG CTG CTG AAC GGA CCG GCC TTC CAG ATG GTA TGC CCC	2854						
804	V R G K F N T T L L N G P A F Q M V C P	823						
2855	ATA GGA TGG ACA GGG ACT GTA AGC TGT ACG TCA TTC AAT ATG GAC ACC TTA GCC ACA ACT	2914						
824	I G W T G T V S C T S F N M D T L A T T	843						
2915	GTG GTA CGG ACA TAT AGA AGG TCT AAA CCA TTC CCT CAT AGG CAA GGC TGT ATC ACC CAA	2974						
844	V V R T Y R R S K P F P H R Q G C I T Q	863						
2975	AAG AAT CTG GGG GAG GAT CTC CAT AAC TGC ATC CTT GGA GGA AAT TGG ACT TGT GTG CCT	3034						
864	K N L G E D L H N C I L G G N W T C V P	883						
3035	GGA GAC CAA CTA CTA TAC AAA GGG GGC TCT ATT GAA TCT TGC AAG TGG TGT GGC TAT CAA	3094						
884	G D Q L L Y K G G S I E S C K W C G Y Q	903						
3095	TTT AAA GAG AGT GAG GGA CTA CCA CAC TAC CCC ATT GGC AAG TGT AAA TTG GAG AAC GAG	3154						
904	F K E S E G L P H Y P I G K C K L E N E	923						
3155	ACT GGT TAC AGG CTA GTA GAC AGT ACC TCT TGC AAT AGA GAA GGT GTG GCC ATA GTA CCA	3214						
924	T G Y R L V D S T S C N R E G V A I V P	943						
3215	CAA GGG ACA TTA AAG TGC AAG ATA GGA AAA ACA ACT GTA CAG GTC ATA GCT ATG GAT ACC	3274						
944	Q G T L K C K I G K T T V Q V I A M D T	963						
3275	AAA CTC GGA CCT ATG CCT TGC AGA CCA TAT GAA ATC ATA TCA AGT GAG GGG CCT GTA GAA	3334						
964	K L G P M P C R P Y E I I S S E G P V E	983						
3335	AAG ACA GCG TGT ACT TTC AAC TAC ACT AAG ACA TTA AAA AAT AAG TAT TTT GAG CCC AGA	3394						
984	K T A C T F N Y T K T L K N K Y F E P R	1003						
3395	GAC AGC TAC TTT CAG CAA TAC ATG CTA AAA GGA GAG TAT CAA TAC TGG TTT GAC CTG GAG	3454						
1004	D S Y P Q Q Y M L K G E Y Q Y W F D L E	1023						
3455	GTG ACT GAC CAT CAC CGG GAT TAC TTC GCT GAG TCC ATA TTA GTG GTG GTA GTA GCC CTC	3514						
1024	V T D H H R D Y F A E S I L V V V V A L	1043						

FIGURE 12-2

BVDV NADL cIns- (inf. clone)		Genes		32/67		4/21/99	5:45:24 PM	Page 3
3515	TTG GGT GGC AGA TAT GTA CTT TGG TTA CTG GTT ACA TAC ATG GTC TTA TCA GAA CAG AAG	3574						
1044	L G G R Y V L W L L V T Y M V L S E Q K	1063						
3575	GCC TTA GGG ATT CAG TAT GGA TCA GGG GAA GTG GTG ATG ATG GGC AAC TTG CTA ACC CAT	3634						
1064	A L G I Q Y G S G E V V M M G N L L T H	1083						
3635	AAC AAT ATT GAA GTG GTG ACA TAC TTC TTG CTG CTG TAC CTA CTG CTG AGG GAG GAG AGC	3694						
1084	N N I E V V T Y F L L L Y L L L R E E S	1103						
3695	GTA AAG AAG TGG GTC TTA CTC TTA TAC CAC ATC TTA GTG GTA CAC CCA ATC AAA TCT GTA	3754						
1104	V K K W V L L L Y H I L V V H P I K S V	1123						
3755	ATT GTG ATC CTA CTG ATG ATT GGG GAT GTG GTA AAG GCC GAT TCA GGG GGC CAA GAG TAC	3814						
1124	I V I L L M I G D V V K A D S G G Q E Y	1143						
3815	TTG GGG AAA ATA GAC CTC TGT TTT ACA ACA GTA GTA CTA ATC GTC ATA GGT TTA ATC ATA	3874						
1144	L G K I D L C F T T V V L I V I G L I I	1163						
3875	GCC AGG CGT GAC CCA ACT ATA GTG CCA CTG GTA ACA ATA ATG GCA GCA CTG AGG GTC ACT	3934						
1164	A R I V P L V T I M A A L R V T	1183						
3935	GAA CTG ACC CAC CAG CCT GGA GTT GAC ATC GCT GTG GCG GTC ATG ACT ATA ACC CTA CTG	3994						
1184	E L T H Q P G V D I A V A V M T I T L L	1203						
3995	ATG GTT AGC TAT GTG ACA GAT TAT TTT AGA TAT AAA AAA TGG TTA CAG TGC ATT CTC AGC	4054						
1204	M V S Y V T D Y F R Y K K W L Q C I L S	1223						
4055	CTG GTA TCT GCG GTG TTC TTG ATA AGA AGC CTA ATA TAC CTA GGT AGA ATC GAG ATG CCA	4114						
1224	L V S A V F L I R S L I Y L G R I E M P	1243						
4115	GAG GTA ACT ATC CCA AAC TGG AGA CCA CTA ACT TTA ATA CTA TTA TAT TTG ATC TCA ACA	4174						
1244	E V T I P N W R P L T L I L L Y L I S T	1263						
4175	ACA ATT GTA ACG AGG TGG AAG GTT GAC GTG GCT GGC CTA TTG TTG CAA TGT GTG CCT ATC	4234						
1264	T I V T R W K V D V A G L L L Q C V P I	1283						
4235	TTA TTG CTG GTC ACA ACC TTG TGG GCC GAC TTC TTA ACC CTA ATA CTG ATC CTG CCT ACC	4294						
1284	L L L V T T L W A D F L T L I L I L P T	1303						
4295	TAT GAA TTG GTT AAA TTA TAC TAT CTG AAA ACT GTT AGG ACT GAT ATA GAA AGA AGT TGG	4354						
1304	Y E L V K L Y Y L K T V R T D I E R S W	1323						
4355	CTA GGG GGG ATA GAC TAT ACA AGA GTT GAC TCC ATC TAC GAC GTT GAT GAG AGT GGA GAG	4414						
1324	L G G I D Y T R V D S I Y D V D E S G E	1343						
4415	GGC GTA TAT CTT TTT CCA TCA AGG CAG AAA GCA CAG GGG AAT TTT TCT ATA CTC TTG CCC	4474						
1344	G V Y L F P S R Q K A Q G N F S I L L P	1363						
4475	CTT ATC AAA GCA ACA CTG ATA AGT TGC GTC AGC AGT AAA TGG CAG CTA ATA TAC ATG AGT	4534						
1364	L I K A T L I S C V S S K W Q L I Y M S	1383						
4535	TAC TTA ACT TTG GAC TTT ATG TAC TAC ATG CAC AGG AAA GTT ATA GAA GAG ATC TCA GGA	4594						
1384	Y L T L D F M Y Y M H R K V I E E I S G	1403						
4595	GGT ACC AAC ATA ATA TCC AGG TTA GTG GCA GCA CTC ATA GAG CTG AAC TGG TCC ATG GAA	4654						
1404	G T N I I S R L V A A L I E L N W S M E	1423						
4655	GAA GAG GAG AGC AAA GGC TTA AAG AAG TTT TAT CTA TTG TCT GGA AGG TTG AGA AAC CTA	4714						
1424	E E E S K G L K K F Y L L S G R L R N L	1443						
4715	ATA ATA AAA CAT AAG GTA AGG AAT GAG ACC GTG GCT TCT TGG TAC GGG GAG GAG GAA GTC	4774						
1444	I I K H K V R N E T V A S W Y G E E E V	1463						
4775	TAC GGT ATG CCA AAG ATC ATG ACT ATA ATC AAG GCC AGT ACA CTG AGT AAG AGC AGG CAC	4834						
1464	Y G M P K I M T I I K A S T L S K S R H	1483						
4835	TGC ATA ATA TGC ACT GTA TGT GAG GGC CGA GAG TGG AAA GGT GGC ACC TGC CCA AAA TGT	4894						
1484	C I I C T V C E G R E W K G G T C P K C	1503						
4895	GGA CGC CAT GGG AAG CCG ATA ACG TGT GGG ATG TCG CTA GCA GAT TTT GAA GAA AGA CAC	4954						
1504	G R H G K P I T C G M S L A D F E R H	1523						
4955	TAT AAA AGA ATC TTT ATA AGG GAA GGC AAC TTT GAG gggccc TTC AGG CAG GAA TAC AAT	5014						
1524	Y K R I F I R E G N F E F R Q E Y N	1541						
5015	GGC TTT GTA CAA TAT ACC GCT AGG GGG CAA CTA TTT CTG AGA AAC TTG CCC GTA CTG GCA	5074						
1542	G F V Q Y T A R G Q L F L R N L P V L A	1561						
5075	ACT AAA GTA AAA ATG CTC ATG GTA GGC AAC CTT GGA GAA GAA ATT GGT AAT CTG GAA CAT	5134						
1562	T K V K M L M V G N L G E E I G N L E H	1581						
5135	CTT GGG TGG ATC CTA AGG GGG CCT GCC GTG TGT AAG AAG ATC ACA GAG CAC GAA AAA TGC	5194						
1582	L G W I L R G P A V C K K I T E H E K C	1601						
5195	CAC ATT AAT ATA CTG GAT AAA CTA ACC GCA TTT TTC GGG ATC ATG CCA AGG GGG ACT ACA	5254						
1602	H I N I L D K L T A F F G I M P R G T T	1621						

FIGURE 12-3

BVDV NADL clns- (inf. clone)		Genes		33/67		4/21/99		5:45:24 PM		Page 4											
5255	CCC	AGA	GCC	CCG	GTG	AGG	TTC	CCT	ACG	AGC	TTA	CTA	AAA	GTG	AGG	AGG	GGT	CTG	GAG	ACT	5314
1622	P	R	A	P	V	R	F	P	T	S	L	L	K	V	R	R	G	L	E	T	1641
5315	GCC	TGG	GCT	TAC	ACA	CAC	CAA	GGC	GGG	ATA	AGT	TCA	GTC	GAC	CAT	GTA	ACC	GCC	OGA	AAA	5374
1642	A	W	A	Y	T	H	Q	G	G	I	S	S	V	D	H	V	T	A	G	K	1661
5375	GAT	CTA	CTG	GTC	TGT	GAC	AGC	ATG	GGA	CGA	ACT	AGA	GTG	GTT	TGC	CAA	AGC	AAC	AAC	AGG	5434
1662	D	L	L	V	C	D	S	M	G	R	T	R	V	V	C	Q	S	N	N	R	1681
5435	TTG	ACC	GAT	GAG	ACA	GAG	TAT	GGC	GTC	AAG	ACT	GAC	TCA	GGG	TGC	CCA	GAC	GGT	GCC	AGA	5494
1682	L	T	D	E	T	E	Y	G	V	K	T	D	S	G	C	P	D	G	A	R	1701
5495	TGT	TAT	GTG	TTA	AAT	CCA	GAG	GCC	GTT	AAC	ATA	TCA	GGA	TCC	AAA	GGG	GCA	GTC	GTT	CAC	5554
1702	C	Y	V	L	N	P	E	A	V	N	I	S	G	S	K	G	A	V	V	H	1721
5555	CTC	CAA	AAG	ACA	GGT	GGA	GAA	TTC	ACG	TGT	GTC	ACC	GCA	TCA	GGC	ACA	CCG	GCT	TTC	TTC	5614
1722	L	Q	K	T	G	G	E	F	T	C	V	T	A	S	G	T	P	A	F	F	1741
5615	GAC	CTA	AAA	AAC	TTG	AAA	GGA	TGG	TCA	GGC	TTG	CCT	ATA	TTT	GAA	GCC	TCC	AGC	GGG	AGG	5674
1742	D	L	K	N	L	K	G	W	S	G	L	P	I	F	E	A	S	S	G	R	1761
5675	GTG	GTT	GGC	AGA	GTC	AAA	GTA	GGG	AAG	AAT	GAA	GAG	TCT	AAA	CCT	ACA	AAA	ATA	ATG	AGT	5734
1762	V	V	G	R	V	K	V	G	K	N	E	E	S	K	P	T	K	I	M	S	1781
5735	GGA	ATC	CAG	ACC	GTC	TCA	AAA	AAC	AGA	GCA	GAC	CTG	ACC	GAG	ATG	GTC	AAG	AAG	ATA	ACC	5794
1782	G	I	Q	T	V	S	K	N	R	A	D	L	T	E	M	V	K	K	I	T	1801
5795	AGC	ATG	AAC	AGG	GGA	GAC	TTC	AAG	CAG	ATT	ACT	TTG	GCA	ACA	GGG	GCA	GGC	AAA	ACC	ACA	5854
1802	S	M	N	R	G	D	F	K	Q	I	T	L	A	T	G	A	G	K	T	T	1821
5855	GAA	CTC	CCA	AAA	GCA	GTT	ATA	GAG	GAG	ATA	GGA	AGA	CAC	AAG	AGA	GTA	TTA	GTT	CTT	ATA	5914
1822	E	L	P	K	A	V	I	E	E	I	G	R	H	K	R	V	L	V	L	I	1841
5915	CCA	TTA	AGG	GCA	GCG	GCA	GAG	TCA	GTC	TAC	CAG	TAT	ATG	AGA	TTG	AAA	CAC	CCA	AGC	ATC	5974
1842	P	L	R	A	A	A	E	S	V	Y	Q	Y	M	R	L	K	H	P	S	I	1861
5975	TCT	TTT	AAC	CTA	AGG	ATA	GGG	GAC	ATG	AAA	GAG	GGG	GAC	ATG	GCA	ACC	GGG	ATA	ACC	TAT	6034
1862	S	F	N	L	R	I	G	D	M	K	E	G	D	M	A	T	G	I	T	Y	1881
6035	GCA	TCA	TAC	GGG	TAC	TTC	TGC	CAA	ATG	CCT	CAA	CCA	AAG	CTC	AGA	GCT	GCT	ATG	GTA	GAA	6094
1882	A	S	Y	G	Y	F	C	Q	M	P	Q	P	K	L	R	A	A	M	V	E	1901
6095	TAC	TCA	TAC	ATA	TTC	TTA	GAT	GAA	TAC	CAT	TGT	GCC	ACT	CCT	GAA	CAA	CTG	GCA	ATT	ATC	6154
1902	Y	S	Y	I	F	L	D	E	Y	H	C	A	T	P	E	Q	L	A	I	I	1921
6155	GGG	AAG	ATC	CAC	AGA	TTT	TCA	GAG	AGT	ATA	AGG	GTT	GTC	GCC	ATG	ACT	GCC	ACG	CCA	GCA	6214
1922	G	K	I	H	R	F	S	E	S	I	R	V	V	A	M	T	A	T	P	A	1941
6215	GGG	TCG	GTG	ACC	ACA	ACA	GGT	CAA	AAG	CAC	CCA	ATA	GAG	GAA	TTC	ATA	GCC	CCC	GAG	GTA	6274
1942	G	S	V	T	T	T	G	Q	K	H	P	I	E	E	F	I	A	P	E	V	1961
6275	ATG	AAA	GGG	GAG	GAT	CTT	GGT	AGT	CAG	TTC	CTT	GAT	ATA	GCA	GGG	TTA	AAA	ATA	CCA	GTG	6334
1962	M	K	G	E	D	L	G	S	Q	F	L	D	I	A	G	L	K	I	P	V	1981
6335	GAT	GAG	ATG	AAA	GGC	AAT	ATG	TTG	GTT	TTT	GTA	CCA	ACG	AGA	AAC	ATG	GCA	GTA	GAG	GTA	6394
1982	D	E	M	K	G	N	M	L	V	F	V	P	T	R	N	M	A	V	E	V	2001
6395	GCA	AAG	AAG	CTA	AAA	GCT	AAG	GGC	TAT	AAC	TCT	GGA	TAC	TAT	TAC	AGT	GGA	GAG	GAT	CCA	6454
2002	A	K	K	L	K	A	K	G	Y	N	S	G	Y	Y	Y	S	G	E	D	P	2021
6455	GCC	AAT	CTG	AGA	GTT	GTG	ACA	TCA	CAA	TCC	CCC	TAT	GTA	ATC	GTG	GCT	ACA	AAT	GCT	ATT	6514
2022	A	N	L	R	V	V	T	S	Q	S	P	Y	V	I	V	A	T	N	A	I	2041
6515	GAA	TCA	GGA	GTG	ACA	CTA	CCA	GAT	TTG	GAC	ACG	GTT	ATA	GAC	ACG	GGG	TTG	AAA	TGT	GAA	6574
2042	E	S	G	V	T	L	P	D	L	D	T	V	I	D	T	G	L	K	C	E	2061
6575	AAG	AGG	GTG	AGG	GTA	TCA	TCA	AAG	ATA	CCC	TTC	ATC	GTA	ACA	GGC	CTT	AAG	AGG	ATG	GCC	6634
2062	K	R	V	R	V	S	S	K	I	P	F	I	V	T	G	L	K	R	M	A	2081
6635	GTG	ACT	GTG	GGT	GAG	CAG	GCG	CAG	CGT	AGG	GGC	AGA	GTA	GGT	AGA	GTG	AAA	CCC	GGG	AGG	6694
2082	V	T	V	G	E	Q	A	Q	R	R	G	R	V	G	R	V	K	P	G	R	2101
6695	TAT	TAT	AGG	AGC	CAG	GAA	ACA	GCA	ACA	GGG	TCA	AAG	GAC	TAC	CAC	TAT	GAC	CTC	TTG	CAG	6754
2102	Y	Y	R	S	Q	E	T	A	T	G	S	K	D	Y	H	Y	D	L	L	Q	2121
6755	GCA	CAA	AGA	TAC	GGG	ATT	GAG	GAT	GGA	ATC	AAC	GTG	ACG	AAA	TCC	TTT	AGG	GAG	ATG	AAT	6814
2122	A	Q	R	Y	G	I	E	D	G	I	N	V	T	K	S	F	R	E	M	N	2141
6815	TAC	GAT	TGG	AGC	CTA	TAC	GAG	GAG	GAC	AGC	CTA	CTA	ATA	ACC	CAG	CTG	GAA	ATA	CTA	AAT	6874
2142	Y	D	W	S	L	Y	E	E	D	S	L	L	I	T	Q	L	E	I	L	N	2161
6875	AAT	CTA	CTC	ATC	TCA	GAA	GAC	TTG	CCA	GCC	GCT	GTT	AAG	AAC	ATA	ATG	GCC	AGG	ACT	GAT	6934
2162	N	L	L	I	S	E	D	L	P	A	A	V	K	N	I	M	A	R	T	D	2181
6935	CAC	CCA	GAG	CCA	ATC	CAA	CTT	GCA	TAC	AAC	AGC	TAT	GAA	GTC	CAG	GTC	CCG	GTC	CTG	TTC	6994
2182	H	P	E	P	I	O	L	A	Y	N	S	Y	E	V	Q	V	P	V	L	F	2201

FIGURE 12-4

FIGURE 12-4

BVDV NADL cIns- (inf. clone)		Genes		34/67		4/21/99	5:45:24 PM	Page 5
6995	CCA AAA ATA AGG AAT GGA GAA GTC ACA GAC ACC TAC GAA AAT TAC TCG TTT CTA AAT GCC	7054						
2202	P K I R N G E V T D T Y E N Y S F L N A	2221						
7055	AGA AAG TTA GGG GAG GAT GTG CCC GTG TAT ATC TAC GCT ACT GAA GAT GAG GAT CTG GCA	7114						
2222	R K L G E D V P V Y I Y A T E D E D L A	2241						
7115	GTG GAC CTC TTA GGG CTA GAC TGG CCT GAT CCT GGG AAC CAG CAG GTA GTG GAG ACT GGT	7174						
2242	V D L L G L D W P D P G N Q Q V V E T G	2261						
7175	AAA GCA CTG AAG CAA GTG ACC GGG TTG TCC TCG GCT GAA AAT GCC CTA CTA GTG GCT TTA	7234						
2262	K A L K Q V T G L S S A E N A L L V A L	2281						
7235	TTT GGG TAT GTG GGT TAC CAG GCT CTC TCA AAG AGG CAT GTC CCA ATG ATA ACA GAC ATA	7294						
2282	F G Y V G Y Q A L S K R H V P M I T D I	2301						
7295	TAT ACC ATC GAG GAC CAG AGA CTA GAA GAC ACC ACC CAC CTC CAG TAT GCA CCC AAC GCC	7354						
2302	Y T I E D Q R L E D T T H L Q Y A P N A	2321						
7355	ATA AAA ACC GAT GGG ACA GAG ACT GAA CTG AAA GAA CTG GCG TCG GGT GAC GTG GAA AAA	7414						
2322	I K T D G T E T E L K E L A S G D V E K	2341						
7415	ATC ATG GGA GCC ATT TCA GAT TAT GCA GCT GGG GGA CTG GAG TTT GTT AAA TCC CAA GCA	7474						
2342	I M G A I S D Y A A G G L E F V K S Q A	2361						
7475	GAA AAG ATA AAA ACA GCT CCT TTG TTT AAA GAA AAC GCA GAA GCC GCA AAA GGG TAT GTC	7534						
2362	E K I K T A P L F K E N A E A A K G Y V	2381						
7535	CAA AAA TTC ATT GAC TCA TTA ATT GAA AAT AAA GAA GAA ATA ATC AGA TAT GGT TTG TGG	7594						
2382	Q K F I D S L I E N K E E I I R Y G L W	2401						
7595	GGA ACA CAC ACA GCA CTA TAC AAA AGC ATA GCT GCA AGA CTG GGG CAT GAA ACA GCG TTT	7654						
2402	G T H T A L Y K S I A A R L G H E T A F	2421						
7655	GCC ACA CTA GTG TTA AAG TGG CTA GCT TTT GGA GGG GAA TCA GTG TCA GAC CAC GTC AAG	7714						
2422	A T L V L K W L A F G G E S V S D H V K	2441						
7715	CAG GCG GCA GTT GAT TTA GTG GTC TAT TAT GTG ATG AAT AAG CCT TCC TTC CCA GGT GAC	7774						
2442	Q A A V D L V V Y Y V M N K P S F P G D	2461						
7775	TCC GAG ACA CAG CAA GAA GGG AGG CGA TTC GTC GCA AGC CTG TTC ATC TCC GCA CTG GCA	7834						
2462	S E T Q Q E G R R F V A S L F I S A L A	2481						
7835	ACC TAC ACA TAC AAA ACT TGG AAT TAC CAC AAT CTC TCT AAA GTG GTG GAA CCA GCC CTG	7894						
2482	T Y T Y K T W N Y H N L S K V V E P A L	2501						
7895	GCT TAC CTC CCC TAT GCT ACC AGC GCA TTA AAA ATG TTC ACC CCA ACG CGG CTG GAG AGC	7954						
2502	A Y L P Y A T S A L K M F T P T R L E S	2521						
7955	GTG GTG ATA CTG AGC ACC ACG ATA TAT AAA ACA TAC CTC TCT ATA AGG AAG GGG AAG AGT	8014						
2522	V V I L S T T I Y K T Y L S I R K G K S	2541						
8015	GAT GGA TTG CTG GGT ACG GGG ATA AGT GCA GCC ATG GAA ATC CTG TCA CAA AAC CCA GTA	8074						
2542	D G L L G T G I S A A M E I L S Q N P V	2561						
8075	TGG GTA GGT ATA TCT GTG ATG TTG GGG GTA GGG GCA ATC GCT GCG CAC AAC GCT ATT GAG	8134						
2562	S V G I S V M L G V G A I A A H N A I E	2581						
8135	TCC AGT GAA CAG AAA AGG ACC CTA CTT ATG AAG GTG TTT GTA AAG AAC TTC TTG GAT CAG	8194						
2582	S S E Q K R T L L M K V F V K N F L D Q	2601						
8195	GCT GCA ACA GAT GAG CTG GTA AAA GAA AAC CCA GAA AAA ATT ATA ATG GCC TTA TTT GAA	8254						
2602	A A T D E L V K E N P E K I I M A L F E	2621						
8255	GCA GTC CAG ACA ATT GGT AAC CCC CTG AGA CTA ATA TAC CAC CTG TAT GGG GTT TAC TAC	8314						
2622	A V Q T I G N P L R L I Y H L Y G V Y Y	2641						
8315	AAA GGT TGG GAG GCC AAG GAA CTA TCT GAG AGG ACA GCA GGC AGA AAC TTA TTC ACA TTG	8374						
2642	K G W E A K E L S E R T A G R N L F T L	2661						
8375	ATA ATG TTT GAA GCC TTC GAG TTA TTA GGG ATG GAC TCA CAA GGG AAA ATA AGG AAC CTG	8434						
2662	I M F E L L G M D S Q G K I R N L	2681						
8435	TCC GGA AAT TAC ATT TTG GAT TTG ATA TAC GGC CTA CAC AAG CAA ATC AAC AGA GGG CTG	8494						
2682	S G N Y I L D L I Y G L H K Q I N R G L	2701						
8495	AAG AAA ATG GTA CTG GGG TGG GCC CCT GCA CCC TTT AGT TGT GAC TGG ACC CCT AGT GAC	8554						
2702	K K M V L G W A P A P F S C D W T P S D	2721						
8555	GAG AGG ATC AGA TTG CCA ACA GAC AAC TAT TTG AGG GTA GAA ACC AGG TGC CCA TGT GGC	8614						
2722	E R I R L P T D N Y L R V E T R C P C G	2741						
8615	TAT GAG ATG AAA GCT TTC AAA AAT GTA GGT GGC AAA CTT ACC AAA GTG GAG GAG AGC GGG	8674						
2742	Y E M K A F K N V G G K L T K V E E S G	2761						
8675	CCT TTC CTA TGT AGA AAC AGA CCT GGT AGG GGA CCA GTC AAC TAC AGA GTC ACC AAG TAT	8734						
2762	P F L C R N R P G R G P V N Y R V T K Y	2781						

FIGURE 12-5

BVDV NADL cIns- (inf. clone)		Genes		35/67		4/21/99		5:45:24 PM		Page 6											
8735	TAC	GAT	GAC	AAC	CTC	AGA	GAG	ATA	AAA	CCA	GTA	GCA	AAG	TTG	GAA	GGA	CAG	GTA	GAG	CAC	8794
2782	Y	D	D	N	L	R	E	I	K	P	V	A	K	L	E	G	Q	V	E	H	2801
8795	TAC	TAC	AAA	GGG	GTC	ACA	GCA	AAA	ATT	GAC	TAC	AGT	AAA	GGA	AAA	ATG	CTC	TTG	GCC	ACT	8854
2802	Y	Y	K	G	V	T	A	K	I	D	Y	S	K	G	K	M	L	L	A	T	2821
8855	GAC	AAG	TGG	GAG	GTG	GAA	CAT	GGT	GTC	ATA	ACC	AGG	TTA	GCT	AAG	AGA	TAT	ACT	GGG	GTC	8914
2822	D	K	W	E	V	E	H	G	V	I	T	R	L	A	K	R	Y	T	G	V	2841
8915	GGG	TTC	AAT	GGT	GCA	TAC	TTA	GGT	GAC	GAG	CCC	AAT	CAC	CGT	GCT	CTA	GTG	GAG	AGG	GAC	8974
2842	G	F	N	G	A	Y	L	G	D	E	P	N	H	R	A	L	V	E	R	D	2861
8975	TGT	GCA	ACT	ATA	ACC	AAA	AAC	ACA	GTA	CAG	TTT	CTA	AAA	ATG	AAG	AAG	GGG	TGT	GCG	TTC	9034
2862	C	A	T	I	T	K	N	T	V	Q	F	L	K	M	K	K	G	C	A	F	2881
9035	ACC	TAT	GAC	CTG	ACC	ATC	TCC	AAT	CTG	ACC	AGG	CTC	ATC	GAA	CTA	GTA	CAC	AGG	AAC	AAT	9094
2882	T	Y	D	L	T	I	S	N	L	T	R	L	I	E	L	V	H	R	N	N	2901
9095	CTT	GAA	GAG	AAG	GAA	ATA	CCC	ACC	GCT	ACG	GTC	ACC	ACA	TGG	CTA	GCT	TAC	ACC	TTC	GTG	9154
2902	L	E	E	K	E	I	P	T	A	T	V	T	T	W	L	A	Y	T	F	V	2921
9155	AAT	GAA	GAC	GTA	GGG	ACT	ATA	AAA	CCA	GTA	CTA	GGA	GAG	AGA	GTA	ATC	CCC	GAC	CCT	GTA	9214
2922	N	E	D	V	G	T	I	K	P	V	L	G	E	R	V	I	P	D	P	V	2941
9215	GTT	GAT	ATC	AAT	TTA	CAA	CCA	GAG	GTG	CAA	GTG	GAC	ACG	TCA	GAG	GTT	GGG	ATC	ACA	ATA	9274
2942	V	D	I	N	L	Q	P	E	V	Q	V	D	T	S	E	V	G	I	T	I	2961
9275	ATT	GGA	AGG	GAA	ACC	CTG	ATG	ACA	ACG	GGA	GTG	ACA	CCT	GTC	TTG	GAA	AAA	GTA	GAG	CCT	9334
2962	I	G	R	E	T	L	M	T	T	G	V	T	P	V	L	E	K	V	E	P	2981
9335	GAC	GCC	AGC	GAC	AAC	CAA	AAC	TCG	GTG	AAG	ATC	GGG	TTG	GAT	GAG	GGT	AAT	TAC	CCA	GGG	9394
2982	D	A	S	D	N	Q	N	S	V	K	I	G	L	D	E	G	N	Y	P	G	3001
9395	CCT	GGA	ATA	CAG	ACA	CAT	ACA	CTA	ACA	GAA	GAA	ATA	CAC	AAC	AGG	GAT	GCG	AGG	CCC	TTC	9454
3002	P	G	I	Q	T	H	T	L	T	E	E	I	H	N	R	D	A	R	P	F	3021
9455	ATC	ATG	ATC	CTG	GGC	TCA	AGG	AAT	TCC	ATA	TCA	AAT	AGG	GCA	AAG	ACT	GCT	AGA	AAT	ATA	9514
3022	I	M	I	L	G	S	R	N	S	I	S	N	R	A	K	T	A	R	N	I	3041
9515	AAT	CTG	TAC	ACA	GGA	AAT	GAC	CCC	AGG	GAA	ATA	CGA	GAC	TTG	ATG	GCT	GCA	GGG	CGC	ATG	9574
3042	N	L	Y	T	G	N	D	P	R	E	I	R	D	L	M	A	A	G	R	M	3061
9575	TTA	GTA	GTA	GCA	CTG	AGG	GAT	GTC	GAC	CCT	GAG	CTG	TCT	GAA	ATG	GTC	GAT	TTC	AAG	GGG	9634
3062	L	V	V	A	L	R	D	V	D	P	E	L	S	E	M	V	D	F	K	G	3081
9635	ACT	TTT	TTA	GAT	AGG	GAG	GCC	CTG	GAG	GCT	CTA	AGT	CTC	GGG	CAA	CCT	AAA	CCG	AAG	CAG	9694
3082	T	F	L	D	R	E	A	L	E	A	L	S	L	G	Q	P	K	P	K	Q	3101
9695	GTT	ACC	AAG	GAA	GCT	GTT	AGG	AAT	TTG	ATA	GAA	CAG	AAA	AAA	GAT	GTG	GAG	ATC	CCT	AAC	9754
3102	V	T	K	E	A	V	R	N	L	I	E	Q	K	K	D	V	E	I	P	N	3121
9755	TGG	TTT	GCA	TCA	GAT	GAC	CCA	GTA	TTT	CTG	GAA	GTG	GCC	TTA	AAA	AAT	GAT	AAG	TAC	TAC	9814
3122	W	F	A	S	D	P	V	F	L	E	V	A	L	K	N	D	K	Y	Y		3141
9815	TTA	GTA	GGA	GAT	GTT	GGA	GAG	CTA	AAA	GAT	CAA	GCT	AAA	GCA	CTT	GGG	GCC	ACG	GAT	CAG	9874
3142	L	V	G	D	V	G	E	L	K	D	Q	A	K	A	L	G	A	T	D	Q	3161
9875	ACA	AGA	ATT	ATA	AAG	GAG	GTA	GGC	TCA	AGG	ACG	TAT	GCC	ATG	AAG	CTA	TCT	AGC	TGG	TTC	9934
3162	T	R	I	I	K	E	V	G	S	R	T	Y	A	M	K	L	S	S	W	F	3181
9935	CTC	AAG	GCA	TCA	AAC	AAA	CAG	ATG	AGT	TTA	ACT	CCA	CTG	TTT	GAG	GAA	TTG	TTG	CTA	CGG	9994
3182	L	K	A	S	N	K	Q	M	S	L	T	P	L	F	E	E	L	L	L	R	3201
9995	TGC	CCA	CCT	GCA	ACT	AAG	AGC	AAT	AAG	GGG	CAC	ATG	GCA	TCA	GCT	TAC	CAA	TTG	GCA	CAG	10054
3202	C	P	P	A	T	K	S	N	K	G	H	M	A	S	A	Y	Q	L	A	Q	3221
10055	GGT	AAC	TGG	GAG	CCC	CTC	GGT	TGC	GGG	GTG	CAC	CTA	GGT	ACA	ATA	CCA	GCC	AGA	AGG	GTG	10114
3222	G	N	W	E	P	L	G	C	G	V	H	L	G	T	I	P	A	R	R	V	3241
10115	AAG	ATA	CAC	CCA	TAT	GAA	GCT	TAC	CTG	AAG	TTG	AAA	GAT	TTC	ATA	GAA	GAA	GAA	GAG	AAG	10174
3242	F	H	E	A	I	R	D	K	I	D	K	S	E	N	R	Q	N	P	E	L	3261
10175	AAA	CCT	AGG	GTT	AAG	GAT	ACA	GTA	ATA	AGA	GAG	CAC	AAC	AAA	TGG	ATA	CTT	AAA	AAA	ATA	10234
3262	K	P	R	V	K	D	T	V	I	R	E	H	N	K	W	I	L	K	K	I	3281
10235	AGG	TTT	CAA	GGA	AAC	CTC	AAC	ACC	AAG	AAA	ATG	CTC	AAC	CCG	GGG	AAA	CTA	TCT	GAA	CAG	10294
3282	R	F	Q	G	N	L	N	T	K	K	M	L	N	P	G	K	L	S	E	Q	3301
10295	TTG	GAC	AGG	GAG	GGG	CGC	AAG	AGG	AAC	ATC	TAC	AAC	CAC	CAG	ATT	GGT	ACT	ATA	ATG	TCA	10354
3302	L	D	R	E	G	R	K	R	N	I	Y	N	H	Q	I	G	T	I	M	S	3321
10355	AGT	GCA	GGC	ATA	AGG	CTG	GAG	AAA	TTG	CCA	ATA	GTG	AGG	GCC	CAA	ACC	GAC	ACC	AAA	ACC	10414
3322	S	A	G	I	R	L	E	K	L	P	I	V	R	A	Q	T	D	T	K	T	3341
10415	TTT	CAT	GAG	GCA	ATA	AGA	GAT	AAG	ATA	GAC	AAG	AGT	GAA	AAC	CGG	CAA	AAT	CCA	GAA	TTG	10474
3342	F	H	E	A	I	R	D	K	I	D	K	S	E	N	R	Q	N	P	E	L	3361

FIGURE 12-6

FIGURE 12-6

BVDV NADL clns- (inf. clone)		Genes	36/67	4/21/99	5:45:24 PM	Page 7
10475	CAC AAC AAA TTG TTG GAG ATT TTC CAC ACG ATA GCC CAA CCC ACC CTG AAA CAC ACC TAC					10534
3362	H N K L L E I F H T I A Q P T L K H T Y					3381
10535	GGT GAG GTG ACG TGG GAG CAA CTT GAG GCG GGG ATA AAT AGA AAG GGG GCA GCA GGC TTC					10594
3382	G E V T W E Q L E A G I N R K G A A G F					3401
10595	CTG GAG AAG AAG AAC ATC GGA GAA GTA TTG GAT TCA GAA AAG CAC CTG GTA GAA CAA TTG					10654
3402	L E K K N I G E V L D S E K H L V E Q L					3421
10655	GTC AGG GAT CTG AAG GCC GGG AGA AAG ATA AAA TAT TAT GAA ACT GCA ATA CCA AAA AAT					10714
3422	V R D L K A G R K I K Y Y E T A I P K N					3441
10715	GAG AAG AGA GAT GTC AGT GAT GAC TGG CAG GCA GGG GAC CTG GTG GTT GAG AAG AGG CCA					10774
3442	E K R D V S D D W Q A G D L V V E K R P					3461
10775	AGA GTT ATC CAA TAC CCT GAA GCC AAG ACA AGG CTA GCC ATC ACT AAG GTC ATG TAT AAC					10834
3462	R V I Q Y P E A K T R L A I T K V M Y N					3481
10835	TGG GTG AAA CAG CAG CCC GTT GTG ATT CCA GGA TAT GAA GGA AAG ACC CCC TTG TTC AAC					10894
3482	W V K Q Q P V V I P G Y E G K T P L F N					3501
10895	ATC TTT GAT AAA GTG AGA AAG GAA TGG GAC TCG TTC AAT GAG CCA GTG GCC GTA AGT TTT					10954
3502	I F D K V R K E W D S F N E P V A V S F					3521
10955	GAC ACC AAA GCC TGG GAC ACT CAA GTG ACT AGT AAG GAT CTG CAA CTT ATT GGA GAA ATC					11014
3522	D T K A W D T Q V T S K D L Q L I G E I					3541
11015	CAG AAA TAT TAC TAT AAG AAG GAG TGG CAC AAG TTC ATT GAC ACC ATC ACC GAC CAC ATG					11074
3542	Q K Y Y Y K K E W H K F I D T I T D H M					3561
11075	ACA GAA GTA CCA GTT ATA ACA GCA GAT GGT GAA GTA TAT ATA AGA AAT GGG CAG AGA GGG					11134
3562	T E V P V I T A D G E V Y I R N G Q R G					3581
11135	AGC GGC CAG CCA GAC ACA AGT GCT GGC AAC AGC ATG TTA AAT GTC CTG ACA ATG ATG TAC					11194
3582	S G Q P D T S A G N S M L N V L T M M Y					3601
11195	GGC TTC TGC GAA AGC ACA GGG GTA CCG TAC AAG AGT TTC AAC AGG GTG GCA AGG ATC CAC					11254
3602	G F C E S T G V P Y K S F N R V A R I H					3621
11255	GTC TGT GGG GAT GAT GGC TTC TTA ATA ACT GAA AAA GGG TTA GGG CTG AAA TTT GCT AAC					11314
3622	V C G D D G F L I T E K G L G L K F A N					3641
11315	AAA GGG ATG CAG ATT CTT CAT GAA GCA GGC AAA CCT CAG AAG ATA ACG GAA GGG GAA AAG					11374
3642	K G M Q I L H E A G K P Q K I T E G E K					3661
11375	ATG AAA GTT GCC TAT AGA TTT GAG GAT ATA GAG TTC TGT TCT CAT ACC CCA GTC CCT GTT					11434
3662	M K V A Y R F E D I E F C S H T P V P V					3681
11435	AGG TGG TCC GAC AAC ACC AGT AGT CAC ATG GCC GGG AGA GAC ACC GCT GTG ATA CTA TCA					11494
3682	R W S D N T S S H M A G R D T A V I L S					3701
11495	AAG ATG GCA ACA AGA TTG GAT TCA AGT GGA GAG AGG GGT ACC ACA GCA TAT GAA AAA GCG					11554
3702	K M A T R L D S S G E R G T T A Y E K A					3721
11555	GTA GCC TTC AGT TTC TTG CTG ATG TAT TCC TGG AAC CCG CTT GTT AGG AGG ATT TGC CTG					11614
3722	V A F S F L L M Y T S W N P L V R R I C L					3741
11615	TTG GTC CTT TCG CAA CAG CCA GAG ACA GAC CCA TCA AAA CAT GCC ACT TAT TAT TAC AAA					11674
3742	L V L S Q Q P E T D P S K H A T Y Y Y K					3761
11675	GGT GAT CCA ATA GGG GCC TAT AAA GAT GTA ATA GGT CCG AAT CTA AGT GAA CTG AAG AGA					11734
3762	G D P I G A Y K D V I G R N L S E L K R					3781
11735	ACA GGC TTT GAG AAA TTG GCA AAT CTA AAC CTA AGC CTG TCC ACG TTG GGG ATC TGG ACT					11794
3782	T G F E K L A N L N L S L S T L G I W T					3801
11795	AAG CAC ACA AGC AAA AGA ATA ATT CAG GAC TGT GTT GCC ATT GGG AAA GAA GAG GGC AAC					11854
3802	K H T S K R I I Q D C V A I G K E E G N					3821
11855	TGG CTA GTT AAC GCC GAC AGG CTG ATA TCC AGC AAA ACT GGC CAC TTA TAC ATA CCT GAT					11914
3822	W L V N A D R L I S S K T G H L Y I P D					3841
11915	AAA GGC TTT ACA TTA CAA GGA AAG CAT TAT GAG CAA CTG CAG CTA AGA ACA GAG ACA AAC					11974
3842	K G F T L Q G K H Y E Q L Q L R T E T N					3861
11975	CCG GTC ATG GGG GTT GGG ACT GAG AGA TAC AAG TTA GGT CCC ATA GTC AAT CTG CTG CTG					12034
3862	P V M G V G T E R Y K L G P I V N L L L					3881
12035	AGA AGG TTG AAA ATT CTG CTC ATG ACG GCC GTC GGC GTC AGC AGC TGA gacaaaatgtatatat					12098
3882	R R L K I L L M T A V G V S S *					3897
12099	tgtaataaattaatccatgtacatagtgatatataaatatagttgggaccgtccacctcaagaagacgacacgccaaca					12178
12179	cgcacagctaaacagtagtcaagattatctacacctcaagataaacactacatttaatgcacacagcacittagctgtatgag					12258
12259	gatacgcgccgacgtctatagttggactaggggaagacctctaacagccccc					12308

FIGURE 12-7

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GTATaatcactcccctgtgaggaactactgtcttcacgcagaaagcgtctagccatggcgtagtatgagtgtcgtgcagcctccag
gacccccctcccgggagagccatagtggctcgcggaaccgggtgagtacaccggaattgccaggacgaccgggtcctttcttgata
aaccgctcaatgcctggagatttgggcgtgccccgcaagactgctagccgagtagtgttgggtcgcgaaaggccttggtactgc
ctgatagggtgcttgcgagtgccccgggaggtctcgtagaccgtgcaccATG

FIGURE 13

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GTaatcactcccctgtgaggaactactgtcttcacgcagaaagcgtctagccatggcgtagtatgagtgtcgtgcagcctccaggac
ccccctcccgggagagccatagtggctgcggaaccggtgagtacaccggaattgccaggacgaccgggtccittcttgataaac
ccgctcaatgcctggagatttggcgtgccccgcaagactgctagccgagtagtgttgggtcgcgaaaggccttgggtactgcctg
atagggtgcttgcgagtgccccgggaggtctcgtagaccgtgcaccATG

FIGURE 14

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GTATacactccaccatgaatcactcccctgtgaggaactactgtcttcacgcagaaagcgtctagccatggcgtagtatgagtgtcg
tgcagcctccaggacccccctccgggagagccatagtggctgcggaaccggtgagtagacccggaattgccaggacgaccggg
tcctttcttgataaacccgctcaatgcttgagattggcggtgccccgcaagactgctagccgagtagtgttgggtcgcgaaaggc
cttgtggtactgcctgatagggtgcttgcgagtgtccccgggaggtctcgtagaccgtgcaccATG

FIGURE 15

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GTATCAGAAGTGCGAATGCTGAacactccaccatgaatcactcccctgtgaggaactactgtcttcacgcagaaa
gcgtctagccatggcgtagtagtgctgcagcctccaggacccccctcccgggagagccatagtggctgcggaaccgggtg
agtacaccggaattgccaggacgaccgggtcctttcttgataaacccgctcaatgcctggagatttggcgtgccccgcaagactg
ctagccgagtagtgttgggtcgcgaaaggccttggtgactgcctgatagggtgcttgcgagtgccccgggaggtctcgtagaccgtg
caccATG

FIGURE 16

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GTATgccagccccctgatggggcgacactccaccatgaatcacccccctgtaggaactactgtcttcacgcagaaagcgtctag
ccatggcgtagtatgagtgtcgtgcagcctccaggacccccctccgggagagccatagtggctgcggaaccggtagtacacc
ggaattgccaggacgaccgggtccttcttgataaacccgctcaatgcctggagatttggcgtgccccgcaagactgtagccga
gtagtgttgggtcgcgaaaggccttgggtactgcctgatagggtgcitgcgagtgccccgggaggtctcgtagaccgtcaccAT
G

FIGURE 17

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GTATTGCAGTTTgccagccccctgatgggggcgacactccaccatgaatcactccccctgtgaggaaactactgtcttcacgc
agaaagcgtctagccatggcgttagtatgagtgtcgtgcagcctccaggacccccctcccgggagagccatagtggctgcggaac
cggtagtacaccggaattgccaggacgaccgggtccctttcttgataaacccgtcaatgcctggagatttgggcgtcccccgcaa
gactgctagccgagtagtgttgggtcgcgaaaggccttgtgtactgcctgatagggtgcttgcgagtccccgggaggtctcgtaga
ccgtgcaccATG

FIGURE 18

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GTATTGCAGTTTgccagcccccctgatgggggcgacactccaccatgaatcactcccctgtgaggaactactgtcttcacgc
agaaagcgtctagccatggcgtagtagtagtgcgtgcagcctccaggacccccctcccgggagagccatagtggtctcggaac
cggtagtacaccggaattgccaggacgaccgggtcctttcttggaiaaaccgcicaatgcctggagatttggcggtgccccgcaa
gactgctagccgagtagtgggtcgcgaaaggccttgggtactgcctgatagggtcctgcgagtgccccgggaggtctcgtaga
ccgtgcaccATGGAGTTGATCACAATGAACTTTATACAAAACATACAAAACAAAAC
CCGTCGGGGTGGAGGAACCTGTTTATGATCAGGCAGGTGATCCCTTATTTGGT
GAAAGGGGAGCAGTCCACCCTCAATCGACGCTAAAGCTCCCACACAAGAGAG
GGGAACGCGATGTTCCAACCAACTTGGCATCCTTACCAAAAAGAGGTGACTGC
AGGTCGGGTAATAGCAGAGGACCTGTGAGCGGGATCTACCTGAAGCCAGGGC
CACTATTTTACCAGGACTATAAAGGTCCCGTCTATCACAGGGCCCCGTGGAGC
TCTTTGAGGAGGGATCCATGTGTGAAACGACTAAACGGATAGGGAGAGTAAC
GGAAGTGACGGAAAGCTGTACCACATTTATGTGTGTATAGATGGATGTATAATA
ATAAAAAGTGCCACGAGAAGTTACCAAGGGTGTTCAGGTGGGTCCATAATAG
GCTTGACTGCCCTCTATGGGTCACAACTTGCTCAGACACGAAAGAAGAGGGAG
CAACAAAAAAGAAAAACACAGAAACCCGACAGACTAGAAAGGGGGAAAAATGAA
AATAGTGCCCAAAGAATCTGAAAAAGACAGCAAAACTAAACCTCCGGATGCTA
CAATAGTGGTGGAAAGGAGTCAATACCAGGTGAGGAAGAAGGGAAAAACCAA
GAGTAAAAACACTCAGGACGGCTTGTACCATAACAAAAACAAACCTCAGGAAT
CACGCAAGAAACTGGAAAAAGCATTGTTGGCGTGGGCAATAATAGCTATAGTT
TTGTTTCAAGTTACAATGGGAGAAAAACATAACACAGTGGAACTACAAGATAAT
GGGACGGAAGGGATACACGCGGCAATGTTCCAAAGGGGTGTGAATAGAAAGTT
TACATGGAATCTGGCCAGAGAAAACTGTACTGGTGTCCCTTCCCATCTAGCCA
CCGATATAGAACTAAAAACAATTCTGGTATGATGGATGCAAGTGAGAAGACC
AACTACACGTGTTGCAGACTTCAACGCCATGAGTGGAAACAAGCATGGTTGGTG
CAACTGGTACAATATTGAACCTGGATTCTAGTCATGAATAGAACCCAAGCCAA
TCTCACTGAGGGACAACCACCAAGGGAGTGCGCAGTCACTTGTAGGTATGATA
GGGCTAGTGACTTAAACGTGGTAACACAAGCTAGAGATAGCCCCACACCCTTA
ACAGGTTGCAAGAAAGGAAAGAACTTCTCCTTTGCAGGCATATTGATGCGGGG
CCCCTGCAACTTTGAAATAGCTGCAAGTGATGTATTATTCAAAGAACATGAACG
CATTAGTATGTTCCAGGATACTACTCTTTACCTTGTGACGGGTGTGACCACTCC
TTAGAAGGTGCCAGACAAGGAACCGCTAAACTGACAACCTGGTTAGGCAAGCA
GCTCGGGATACTAGGAAAAAAGTTGGAAAAACAAGAGTAAGACGTGGTTTGGAG
CATACGCTGCTTCCCCTTACTGTGATGTCGATCGCAAAATTGGCTACATATGGT
ATACAAAAAATTGCACCCCTGCCTGCTTACCCAAGAACACAAAAATTGTCGGCC
CTGGGAAATTGACACCAATGCAGAGGACGGCAAGATATTACATGAGATGGGG
GGTCACTTGTGCGGAGGTACTACTCTTTCTTTAGTGGTGCTGTCCGACTTCGCA
CCGGAACAGCTAGTGTAAATGTACCTAATCCTACATTTTTCCATCCCACAAAGTC
ACGTTGATGTAATGGATTGTGATAAGACCCAGTTGAACCTCACAGTGGAGCTG
ACAACAGCTGAAGTAATACCAGGGTCGGTCTGGAATCTAGGCAATATGTATG
TATAAGACCAAAATTGGTGGCCTTATGAGACAACTGTAGTGTGTCATTGGAAGA
GGTGAGCCAGGTGGTGAAGTTAGTGTGAGGGCACTCAGAGATTTAACACGCA
TTTGAACGCTGCAACAACACTACTGCTTTTTTATGATGCCTTGTAAAGATAGTCAG
GGGCCAGATGGTACAGGGCATTCTGTGGCTACTATTGATAACAGGGGTACAAG
GGCACTTGGATTGCAAACCTGAATTCTCGTATGCCATAGCAAAGGACGAAAGA
ATTGGTCAACTGGGGGCTGAAGGCCTTACCACCACTTGAAGGAATACTCACC
TGGAATGAAGCTGGAAGACACAATGGTCATTGCTTGGTGCGAAGATGGGAAGT
TAATGTACCTCCAAAGATGCACGAGAGAAACCAGGTATCTCGCAATCTTGCATA
CAAGAGCCTTGCCGACCAGTGTGGTATTCAAAAAACTCTTTGATGGGCGAAAG

FIGURE 19-1

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CAAGAGGATGTAGTCGAAATGAACGACAACCTTTGAATTTGGACTCTGCCCATGT
GATGCCAAACCCATAGTAAGAGGGAAGTTCAATACAACGCTGCTGAACGGACC
GGCCTTCCAGATGGTATGCCCCATAGGATGGACAGGGACTGTAAGCTGTACGT
CATTCAATATGGACACCTTAGCCACAACCTGTGGTACGGACATATAGAAGGTCTA
AACCATTCCCTCATAGGCAAGGCTGTATCACCCAAAAGAATCTGGGGGAGGAT
CTCCATAACTGCATCCTTGGAGGAAATTGGACTTGTGTGCCTGGAGACCAACTA
CTATACAAAGGGGGCTCTATTGAATCTTGCAAGTGGTGTGGCTATCAATTTAAA
GAGAGTGAGGGACTACCACACTACCCATTGGCAAGTGTAAATTGGAGAACGA
GACTGGTTACAGGCTAGTAGACAGTACCTCTTGCAATAGAGAAGGTGTGGCCA
TAGTACCACAAGGGACATTAAAGTGCAAGATAGGAAAAACAACCTGTACAGGTC
ATAGCTATGGATACCAAACTCGGACCTATGCCTTGACAGCCATATGAAATCATA
TCAAGTGAGGGGCCTGTAGAAAAGACAGCGTGTACTTTCAACTACACTAAGAC
ATTAATAAATAAGTATTTTGAGCCCAGAGACAGCTACTTTACAGCAATACATGCT
AAAAGGAGAGTATCAATACTGGTTTGACCTGGAGGTGACTGACCATCACCGGG
ATTACTTCGCTGAGTCCATATTAGTGGTGGTAGTAGCCCTCTTGGGTGCCAGAT
ATGTACTTTGGTTACTGGTTACATACATGGTCTTATCAGAACAGAAGGCCTTAG
GGATTCAGTATGGATCAGGGGAAGTGGTGTATGATGGGCAACTTGCTAACCCAT
AACAATATTGAAGTGGTGACATACTTCTTGCTGCTGTACCTACTGCTGAGGGAG
GAGAGCGTAAAGAAGTGGGTCTTACTCTTATACCACATCTTAGTGGTACACCCA
ATCAAATCTGTAATTGTGATCCTACTGATGATTGGGGATGTGGTAAAGGCCGAT
TCAGGGGGCCAAGAGTACTTGGGGAAAATAGACCTCTGTTTTACAACAGTAGT
ACTAATCGTCATAGGTTTAAATCATAGCCAGGCGTGACCCAACCTATAGTGCCACT
GGTAACAATAATGGCAGCACTGAGGGTCACTGAACTGACCCACCAGCCTGGAG
TTGACATCGCTGTGGCGGTGATGACTATAACCCCTACTGATGGTTAGCTATGTGA
CAGATTATTTTATAGATATAAAAAATGGTTACAGTGCATTCTCAGCCTGGTATCTGC
GGTGTCTTGATAAGAAGCCTAATATACCTAGGTAGAATCGAGATGCCAGAGG
TAACTATCCCAAACCTGGAGACCACTAACCTTAACTACTATTATTTGATCTCAAC
AACAATTGTAACGAGGTGGAAGGTTGACGTGGCTGGCCTATTGTTGCAATTGTG
TGCCTATCTTATTGCTGGTCACAACCTTGTGGGCCGACTTCTTAAACCCTAATACT
GATCTGCCTACCTATGAATTGGTTAAATTATACTATCTGAAAACCTGTTAGGACT
GATATAGAAAGAAGTTGGCTAGGGGGGATAGACTATAACAAGAGTTGACTCCAT
CTACGACGTTGATGAGAGTGGAGAGGGCGTATATCTTTTTCCATCAAGGCAGA
AAGCACAGGGGAATTTTTCTATACTCTTGCCCCTTATCAAAGCAACACTGATAA
GTTGCGTCAGCAGTAAATGGCAGCTAATATACATGAGTTACTTAACTTTGGACT
TTATGTACTACATGCACAGGAAAGTTATAGAAGAGATCTCAGGAGGTACCAACA
TAATATCCAGGTTAGTGGCAGCACTCATAGAGCTGAACTGGTCCATGGAAGAA
GAGGAGAGCAAAGGCTTAAAGAAGTTTTATCTATTGTCTGGAAGGTTGAGAAA
CCTAATAATAAAACATAAGGTAAGGAATGAGACCGTGGCTTCTTGGTACGGGG
AGGAGGAAGTCTACGGTATGCCAAAGATCATGACTATAATCAAGGCCAGTACA
CTGAGTAAGAGCAGGCACTGCATAATATGCACTGTATGTGAGGGCCGAGAGTG
GAAAGGTGGCACCTGCCCAAATGTGGACGCCATGGGAAGCCGATAACGTGT
GGGATGTCGCTAGCAGATTTTGAAGAAAGACACTATAAAAGAATCTTTATAAGG
GAAGGCAACTTTGAGGGTATGTGCAGCCGATGCCAGGGAAAGCATAGGAGGT
TTGAAATGGACCGGGAACCTAAGAGTGCCAGATACTGTGCTGAGTGTAATAGG
CTGCATCCTGCTGAGGAAGGTGACTTTTGGGCAGAGTCGAGCATGTTGGGCCT
CAAAATCACCTACTTTGCGCTGATGGATGGAAAGGTGTATGATATCACAGAGTG
GGCTGGATGCCAGCGTGTGGGAATCTCCCCAGATACCCACAGAGTCCCTTGTG
ACATCTCATTTGGTTCACGGATGCCTTTTCAGGCAGGAATACAATGGCTTTGTAC
AATATACCGCTAGGGGGCAACTATTTCTGAGAACTTGCCCGTACTGGCAACTA
AAGTAAAAATGCTCATGGTAGGCAACCTTGAGAGAAGAAATTGGTAATCTGGAA
CATCTTGGGTGGATCCTAAGGGGGCCTGCCGTGTGTAAGAAGATCACAGAGCA
CGAAAAATGCCACATTAATACTGGATAAACTAACC GCATTTTTCGGGATCAT
GCCAAGGGGGACTACCCAGAGCCCCGGTGAGGTTCCCTACGAGCTTACTAA
AAGTGAGGAGGGGTCTGGAGACTGCCTGGGCTTACACACACCAAGGCCGGAT

FIGURE 19-2

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AAGTTCAGTCGACCATGTAACCGCCGGAAAAAGATCTACTGGTCTGTGACAGCA
TGGGACGAACTAGAGTGGTTTGGCAAAGCAACAACAGGTTGACCGATGAGACA
GAGTATGGCGTCAAGACTGACTCAGGGTGCCAGACGGTGCCAGATGTTATGT
GTTAAATCCAGAGGCCGTTAACATATCAGGATCCAAAGGGGCGAGTCGTTACC
TCCAAAAGACAGGTGGAGAATTCACGTGTGTCACCGCATCAGGCACACCGGCT
TTCTTCGACCTAAAAAACTTGAAAGGATGGTCAGGCTTGCCTATATTTGAAGCC
TCCAGCGGGAGGGTGGTTGGCAGAGTCAAAGTAGGGAAGAATGAAGAGTCTA
AACCTACAAAAATAATGAGTGGAAATCCAGACCGTCTCAAAAAACAGAGCAGAC
CTGACCGAGATGGTCAAGAAGATAACCAGCATGAACAGGGGAGACTTCAAGCA
GATTACTTTGGCAACAGGGGCAGGCAAAACCACAGAAGTCCCAAAAGCAGTTA
TAGAGGAGATAGGAAGACACAAGAGAGTATTAGTTCTTATACCATTAAGGGCA
GCGGCAGAGTCAGTCTACCAGTATATGAGATTGAAACACCCAAGCATCTCTTTT
AACCTAAGGATAGGGGACATGAAAGAGGGGGACATGGCAACCGGGATAACCT
ATGCATCATACGGGTACTTCTGCCAAATGCCTCAACCAAGCTCAGAGCTGCTA
TGGTAGAATACTCATACATATTCTTAGATGAATACCATTTGTGCCACTCCTGAACA
ACTGGCAATTATCGGGAAGATCCACAGATTTTTCAGAGAGTATAAGGGTTGTCTG
CCATGACTGCCACGCCAGCAGGGTCGGTGACCACAACAGGTCAAAAGCACCCCA
ATAGAGGAATTCATAGCCCCCGAGGTAATGAAAGGGGAGGATCTTGGTAGTCA
GTTCTTGATATAGCAGGGTTAAAAATACCAGTGGATGAGATGAAAGGCAATAT
GTTGGTTTTTGTACCAACGAGAAACATGGCAGTAGAGGTAGCAAAGAAGCTAA
AAGCTAAGGGCTATAACTCTGGATACTATTACAGTGGAGAGGATCCAGCCAAT
CTGAGAGTTGTGACATCACAATCCCCCTATGTAATCGTGGCTACAAATGCTATT
GAATCAGGAGTGACACTACCAGATTTTGACACGGTTATAGACACGGGGTTGAA
ATGTGAAAAGAGGGTGAGGGTATCATCAAAGATACCCTTCATCGTAACAGGCC
TTAAGAGGATGGCCGTGACTGTGGGTGAGCAGGCGCAGCGTAGGGGCAGAGT
AGGTAGAGTGAAACCCGGGAGGTATTATAGGAGCCAGGAAACAGCAACAGGG
TCAAAGGACTACCACTATGACCTCTTGACGGCACAAGATACGGGATTGAGGA
TGGAATCAACGTGACGAAATCCTTTAGGGAGATGAATTACGATTGGAGCCTATA
CGAGGAGGACAGCCTACTAATAACCCAGCTGGAAATACTAAATAATCTACTCAT
CTCAGAAGACTTGCCAGCCGCTGTAAAGAACATAATGGCCAGGACTGATCACC
CAGAGCCAATCCAACCTTGATACAAACAGCTATGAAGTCCAGGTCCCGGTCTGT
TCCCAAAAATAAGGAATGGAGAAGTCACAGACACCTACGAAAATTACTCGTTTC
TAAATGCCAGAAAGTTAGGGGAGGATGTGCCCGTGTATATCTACGCTACTGAA
GATGAGGATCTGGCAGTTGACCTCTTAGGGCTAGACTGGCCTGATCCTGGGAA
CCAGCAGGTAGTGGAGACTGGTAAAGCACTGAAGCAAGTGACCGGGTTGTCCT
CGGCTGAAAATGCCCTACTAGTGGCTTTATTTGGGTATGTGGGTTACCAGGCTC
TCTCAAAGAGGCATGTCCCAATGATAACAGACATATATACCATCGAGGACCAGA
GACTAGAAGACACCACCCACCTCCAGTATGCACCCAACGCCATAAAAAACCGAT
GGGACAGAGACTGAACTGAAAGAACTGGCGTCGGGTGACGTGGAAAAAATCA
TGGGAGCCATTTTCAGATTATGCAGCTGGGGGACTGGAGTTTGTAAATCCCAA
GCAGAAAAGATAAAAAACAGCTCCTTTGTTTAAAGAAAACGCAGAAGCCGCAAA
AGGGTATGTCCAAAAATTCATTGACTCATTAAATTGAAAATAAAGAAGAAATAAT
CAGATATGGTTTGTGGGAACACACACAGCACTATACAAAAGCATAGCTGCAA
GACTGGGGCATGAAACAGCGTTTGCCACACTAGTGTTAAAGTGGCTAGCTTTT
GGAGGGGAATCAGTGTGAGACCACGTCAAGCAGGCGGCAGTTGATTTAGTGG
TCTATTATGTGATGAATAAGCCTTCCTTCCAGGTGACTCCGAGACACAGCAAG
AAGGGAGGCGATTTCGTGCAAGCCTGTTTCATCTCCGCACTGGCAACCTACACA
TACAAAACCTTGAATTACCACAATCTCTCTAAAGTGGTGGAAACAGCCCTGGCT
TACCTCCCCTATGCTACCAGCGCATTAATAATGTTACCCCAACGCGGCTGGAG
AGCGTGGTGATACTGAGCACCACGATATATAAAACATACTCTCTATAAGGAAG
GGGAAGAGTGATGGATTGCTGGGTACGGGGATAAGTGCAGCCATGGAAATCC
TGTCACAAAACCCAGTATCGGTAGGTATATCTGTGATGTTGGGGGTAGGGGCA
ATCGCTGCGCACAACGCTATTGAGTCCAGTGAACAGAAAAGGACCCTACTTAT
GAAGGTGTTTGTAAAGAACTTCTTGGATCAGGCTGCAACAGATGAGCTGGTAA

FIGURE 19-3

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AAGAAAACCCAGAAAAAATTATAATGGCCTTATTTGAAGCAGTCCAGACAATTG
GTAACCCCTGAGACTAATATACCACCTGTATGGGGTTTACTACAAAGGTTGGG
AGGCCAAGGAATCTGAGAGGACAGCAGGCAGAACTTATTCACATTGATA
ATGTTTGAAGCCTTCGAGTTATTAGGGATGGACTCACAAGGGAAAAATAAGGAA
CCTGTCCGGAAATTACATTTTGGATTGATATACGGCCTACACAAGCAAATCAA
CAGAGGGCTGAAGAAAATGGTACTGGGGTGGGCCCCTGCACCCTTTAGTTGTG
ACTGGACCCCTAGTGACGAGAGGATCAGATTGCCAACAGACAACCTATTTGAGG
GTAGAAACCAAGGTGCCCATGTGGCTATGAGATGAAAGCTTTCAAAAATGTAGG
TGGCAAACCTTACCAAAGTGGAGGAGAGCGGGCCTTTCCTATGTAGAAACAGAC
CTGGTAGGGGACCAGTCAACTACAGAGTACCAAGTATTACGATGACAACCTC
AGAGAGATAAAACCAGTAGCAAAGTTGGAAGGACAGGTAGACACTACTACAA
AGGGGTCACAGCAAAAATTGACTACAGTAAAGGAAAAATGCTCTTGGCCACTG
ACAAGTGGGAGGTGGAACATGGTGTCTATAACCAGGTAGCTAAGAGATATACT
GGGGTCGGGTTCAATGGTGCATACTTAGGTGACGAGCCCAATCACCGTGCTCT
AGTGGAGAGGGACTGTGCAACTATAACCAAAAACACAGTACAGTTTCTAAAAAT
GAAGAAGGGGTGTGCGTTCACCTATGACCTGACCATCTCCAATCTGACCAGGC
TCATCGAACTAGTACACAGGAACAATCTTGAAGAGAAGGAAATACCCACCGCT
ACGGTCACCATATGGCTAGCTTACACCTTCGTGAATGAAGACGTAGGGACTAT
AAAACCACTAGTAGGAGAGAGAGTAATCCCCGACCCTGTAGTTGATATCAATTT
ACAACAGAGGTGCAAGTGGACACGTGAGAGTTGGGATCACAATAATTGGAA
GGGAAACCTGATGACAACGGGAGTGACACCTGTCTTGGAAAAAGTAGAGCCT
GACGCCAGCGACAACCAAACTCGGTGAAGATCGGGTTGGATGAGGGTAATTA
CCCAGGGCCTGGAATACAGACACATACTAACAGAAGAAATACACAACAGGG
ATGCGAGGCCCTTCATCATGATCCTGGGCTCAAGGAATTCCATATCAAATAGGG
CAAAGACTGCTAGAAATATAAATCTGTACACAGGAAATGACCCAGGGAAATA
CGAGACTTGATGGCTGCAGGCGCATGTTAGTAGTAGCACTGAGGGATGTCTGA
CCCTGAGCTGTCTGAAATGGTTCGATTTCAAGGGGACTTTTTTAGATAGGGAGG
CCCTGGAGGCTCTAAGTCTCGGGCAACCTAAACCGAAGCAGGTTACCAAGGAA
GCTGTTAGGAATTTGATAGAACAGAAAAAGATGTGGAGATCCCTAACTGGTTT
GCATCAGATGACCCAGTATTTCTGGAAGTGGCCTTAAAAAATGATAAGTACTAC
TTAGTAGGAGATGTTGGAGAGCTAAAAGATCAAGCTAAAGCACTTGGGGCCAC
GGATCAGACAAGAATTATAAAGGAGGTAGGCTCAAGGACGTATGCCATGAAGC
TATCTAGCTGGTTCCTCAAGGCATCAAACAAACAGATGAGTTTAACTCCACTGT
TTGAGGAATTGTTGCTACGGTGCCACCTGCAACTAAGAGCAATAAGGGGCAC
ATGGCATCAGCTTACCAATTGGCACAGGGTAAGTGGGAGCCCTCGGTTGCGG
GGTGACCTAGGTACAATACCAGCCAGAAGGGTGAAGATACCCCATATGAAG
CTTACCTGAAGTTGAAAGATTTCATAGAAGAAGAAGAGAAGAAACCTAGGGTT
AAGGATACAGTAATAAGAGAGCACAACAAATGGTACTTAAAAAATAAGGTTT
CAAGGAAACCTCAACACCAAGAAAATGCTCAACCCGGGGAACTATCTGAACA
GTTGGACAGGGAGGGGCGCAAGAGGAACATCTACAACCACAGATTGGTACT
ATAATGTCAAGTGCAGGCATAAGGCTGGAGAAATTGCCAATAGTGAGGGCCCA
AACCGACACCAAAACCTTTTCATGAGGCAATAAGAGATAAGATAGACAAGAGTG
AAAACCGGCAAAATCCAGAATTGCACAACAAATTGTTGGAGATTTTCCACACGA
TAGCCCAACCCACCTGAAACACACCTACGGTGAGGTGACGTGGGAGCAACTT
GAGGCGGGGATAAATAGAAAGGGGGCAGCAGGCTTCCTGGAGAAGAAGAACA
TCGGAGAAGTATTGGATTGAGAAAAGCACCTGGTAGAACAATTGGTCAGGGAT
CTGAAGGCCGGGAGAAAGATAAAATATTATGAACTGCAATACCAAAAAATGA
GAAGAGAGATGTCAGTGATGACTGGCAGGCAGGGGACCTGGTGGTTGAGAAG
AGGCCAAGAGTTATCCAATACCCTGAAGCCAAAGACAAGGCTAGGCATCACTAA
GGTCATGTATAACTGGGTGAAACAGCAGCCCCGTTGTGATTCCAGGATATGAAG
GAAAGACCCCTTGTTCACATCTTTGATAAAGTGAGAAAGGAATGGGACTCGT
TCAATGAGCCAGTGGCCGTAAAGTTTTGACACCAAGCCTGGGACACTCAAGTG
ACTAGTAAGGATCTGCAACTTATTGGAGAAATCCAGAAATATTACTATAAGAAG
GAGTGGCACAAGTTCATTGACACCATCACCGACCACATGACAGAAGTACCAGT

FIGURE 19-4

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[illegible]

FIGURE 19-5

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	AATCTGCTCATGACGGCCGTCGGCGTCAGCAGCTGAAGGTTGGGGTAAACACTCCGGCCTCTTAGGCCA	
	10 20 30 40 50 60 70	
3H3Bfrag	AATCTGCTCATGACGGCCGTCGGCGTCAGCAGCTGAAGGTTGGGGTAAACACTCCGGCCTCTTAGGCCA	70
1.1.4 seq	AATCTGCTCATGACGGCCGTCGGCGTCAGCAGCTGAAGGTTGGGGTAAACACTCCGGCCTCTTAGGCCA	70
1.2.3 seq	AATCTGCTCATGACGGCCGTCGGCGTCAGCAGCTGAAGGTTGGGGTAAACACTCCGGCCTCTTAGGCCA	70
6.2.2 seq	AATCTGCTCATGACGGCCGTCGGCGTCAGCAGCTGAAGGTTGGGGTAAACACTCCGGCCTCTTAGGCCA	70
6.1.4 seq	AATCTGCTCATGACGGCCGTCGGCGTCAGCAGCTGAAGGTTGGGGTAAACACTCCGGCCTCTTAGGCCA	70
	TTTCCTGTTTTTTTTTTTTTTTTTTTTTTT	
	80 90 100 110 120 130 140	
3H3Bfrag	TTTCCTGTTTTTTTTTTTTTTTTTTTTTTT	140
1.1.4 seq	TTTCCTGTTTTTTTTTTTTTTTTTTTTTTT	109
1.2.3 seq	TTTCCTGTTTTTTTTTTTTTTTTTTTTTTT	102
6.2.2 seq	TTTCCTGTTTTTTTTTTTTTTTTTTTTTTT	99
6.1.4 seq	TTTCCTGTTTTTTT	84
	CTTTCCTTCTTTTTTTCCTTTCTTTTCCTTCCTTCTTTAATG	
	150 160 170 180 190 200 210	
3H3Bfrag	TTTTTCTCTTTTTTTTTTTTTTTTTTTTCTTTCCTTTCTTTTCCTTCCTTCTTTAATG	210
1.1.4 seq	TTTTTCTCTTTTTTTTTTTTTTTTTTTTCTTTCCTTTCTTTTCCTTCCTTCTTTAATG	149
1.2.3 seq	TTTTTCTCTTTTTTTTTTTTTTTTTTTTCTTTCCTTTCTTTTCCTTCCTTCTTTAATG	142
6.2.2 seq	TTTTTCTCTTTTTTTTTTTTTTTTTTTTCTTTCCTTTCTTTTCCTTCCTTCTTTAATG	140
6.1.4 seq	TTTTTCTCTTTTTTTTTTTTTTTTTTTTCTTTCCTTTCTTTTCCTTCCTTCTTTAATG	125
	GTGGCTCCATCTTAGCCCTAGTCACGGCTAGCTGTGAAAGGTCGGTGAGCCGCATGACTGCAGAGAGTGC	
	220 230 240 250 260 270 280	
3H3Bfrag	GTGGCTCCATCTTAGCCCTAGTCACGGCTAGCTGTGAAAGGTCGGTGAGCCGCATGACTGCAGAGAGTGC	280
1.1.4 seq	GTGGCTCCATCTTAGCCCTAGTCACGGCTAGCTGTGAAAGGTCGGTGAGCCGCATGACTGCAGAGAGTGC	219
1.2.3 seq	GTGGCTCCATCTTAGCCCTAGTCACGGCTAGCTGTGAAAGGTCGGTGAGCCGCATGACTGCAGAGAGTGC	212
6.2.2 seq	GTGGCTCCATCTTAGCCCTAGTCACGGCTAGCTGTGAAAGGTCGGTGAGCCGCATGACTGCAGAGAGTGC	210
6.1.4 seq	GTGGCTCCATCTTAGCCCTAGTCACGGCTAGCTGTGAAAGGTCGGTGAGCCGCATGACTGCAGAGAGTGC	195
	TGATACTGGCCTCTCTGCAGATCATGTCCCCCGGCCGTCGGCGTCAGCAGCTGAGACAAATGTATATAT	
	290 300 310 320 330 340 350	
3H3Bfrag	TGATACTGGCCTCTCTGCAGATCATGTCCCCCGGCCGTCGGCGTCAGCAGCTGAGACAAATGTATATAT	350
1.1.4 seq	TGATACTGGCCTCTCTGCAGATCATGTCCCCCGGCCGTCGGCGTCAGCAGCTGAGACAAATGTATATAT	289
1.2.3 seq	TGATACTGGCCTCTCTGCAGATCATGTCCCCCGGCCGTCGGCGTCAGCAGCTGAGACAAATGTATATAT	282
6.2.2 seq	TGATACTGGCCTCTCTGCAGATCATGTCCCCCGGCCGTCGGCGTCAGCAGCTGAGACAAATGTATATAT	280
6.1.4 seq	TGATACTGGCCTCTCTGCAGATCATGTCCCCCGGCCGTCGGCGTCAGCAGCTGAGACAAATGTATATAT	265
	TGTAAATAAATTAATCCATGTACATAGTGTATATAAATATAGTTGGGACCGT	
	360 370 380 390 400	
3H3Bfrag	TGTAAATAAATTAATCCATGTACATAGTGTATATAAATATAGTTGGGACCGT	402
1.1.4 seq	TGTAAATAAATTAATCCATGTACATAGTGTATATAAATATAGTTGGGACCGT	341
1.2.3 seq	TGTAAATAAATTAATCCATGTACATAGTGTATATAAATATAGTTGGGACCGT	334
6.2.2 seq	TGTAAATAAATTAATCCATGTACATAGTGTATATAAATATAGTTGGGACCGT	332
6.1.4 seq	TGTAAATAAATTAATCCATGTACATAGTGTATATAAATATAGTTGGGACCGT	317

FIGURE 20

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HCV/BVDV chimera

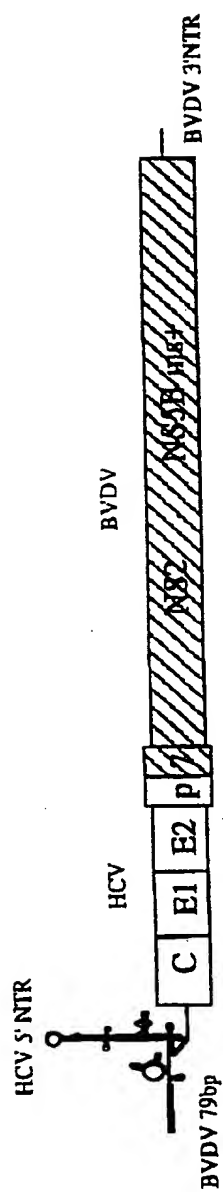


FIGURE 21

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Gtatacgagaattagaaaaggcactcgtataggtggcaataaaaaataaattaggcctagggtacatggcacgtgccagccccct
gatgggggacactccaccatgaatcactcccctgtgaggaactactgtcttcacgcagaaagcgtctagccatggcgtagtatgag
tgtcgtgcagcctccaggacccccctccgggagagccatagtggctgcggaaccggtagtacaccggaattgccaggacgac
cgggtcctttcttgataaaccgctcaatgcctggagattgggcgtgccccgcaagactgctagccgagtagtgggtcgcgaa
aggccttgggtactgcctgatagggtgctgagtgccccgggaggtctcgtagaccgtgcaccATGAGCACGAATC
CTAAACCTCAAAGAAAAACCAACGTAACACCAACCGTCGCCACAGGACGTC
AAGTTCCCGGGTGGCGGTACAGATCGTTGGTGGAGTTTACTTGTGCGCGCAG
GGGCCCTAGATTGGGTGTGCGCGCGACGAGGAAGACTTCCGAGCGGTGCGAA
CCTCGAGGTAGACGTCAGCCTATCCCCAAGGCACGTGCGCCCCGAGGGCAGGA
CCTGGGCTCAGCCCGGGTACCCTTGGCCCCCTCTATGGCAATGAGGGTTGCGGG
TGGGCGGGATGGCTCCTGTCTCCCCGTGGCTCTCGGCCTAGCTGGGGCCCCAC
AGACCCCCGGCGTAGGTGCGGCAATTTGGGTAAGGTCATCGATAACCTTACGT
GCGGCTTCGCCGACCTCATGGGGTACATACCGCTCGTCGGCGCCCCCTCTTGGA
GGCGTGCCAGGGCCCTGGCGCATGGCGTCCGGGTTCTGGAAGACGGCGTGA
ACTATGCAACAGGGAACCTTCTGGTTGCTCTTTCTCTATCTTCTCTGGCCCT
GCTCTCTTGCTGACCGTGCCCGCTTCAGCCTACCAAGTGCGCAATTCCTCGGG
GCTTTACCATGTCACCAATGATTGCCCTAACTCGAGTATTGTGTACGAGGCGGC
CGATGCCATCCTGCACACTCCGGGGTGTGTCCCTTGCCTTCGCGAGGGTAACG
CCTCGAGGTGTTGGGTGGCGGTGACCCCCACGGTGGCCACCAGGGACGGCAA
ACTCCCCACAACGCAGCTTCGACGTCATATCGATCTGCTTGTGCGGGAGCGCCA
CCCTCTGCTCGGCCCTCTACGTGGGGGACCTGTGCGGGTCTGTCTTTCTTGTG
GTCAACTGTTTACCTTCTCTCCAGGCGCCACTGGACGACGCAAGACTGCAATT
GTTCTATCTATCCCGGCCATATAACGGGTGTCATCGCATGGCATGGGATATGATGA
TGAAGTGGTCCCCTACGGCAGCGTTGGTGGTAGCTCAGCTGCTCCGGATCCCCA
CAAGCCATCATGGACATGATCGCTGGTGTCTCACTGGGGAGTCCTGGCGGGCAT
AGCGTATTTCTCCATGGTGGGGAACCTGGGCGAAGGTCCTGGTAGTGCTGCTGC
TATTTGCCGGCGTCGACGCGGAAACCCACGTACCGGGGGGAAGTGCCGGCCG
CACCACGGCTGGGCTTGTGGTCTCCTTACACCAGGCGCCAAGCAGAACATCC
AACTGATCAACACCAACGGCAGTTGGCACATCAATAGCACGGCCTTGAAGTGC
AATGAAAGCCTTAACACCGGCTGGTTAGCAGGGCTCTTCTATCAGCACAAATTC
AACTCTTACGGCTGTCTGAGAGGTTGGCCAGCTGCCGACGCCTTACCGATTTT
GCCCAGGGCTGGGGTCTATCAGTTATGCCAACGGAAGCGGCCTCGACGAAC
GCCCCTACTGCTGGCACTACCCTCCAAGACCTTGTGGCATTGTGCCCGCAAAG
AGCGTGTGTGGCCCGGTATATTGCTTCACTCCCAGCCCCGTGGTGGTGGGAAC
GACCGACAGGTGCGGCGCGCCTACCTACAGCTGGGGTGCAAATGATACGGAT
GTCTTCGTCTTAACAACACCAGGCCACCGCTGGGCAATTGGTTGCGTTGTACC
TGGATGAACTCAACTGGATTACCAAAGTGTGCGGAGCGCCCCCTTGTGTAT
CGGAGGGGTGGGCAACAACACCTTGTCTGCCCCACTGATTGTTTCCGCAAGC
ATCCGGAAGCCACATACTCTCGGTGCGGCTCCGGTCCCTGGATTACACCCAGG
TGCATGGTCTGACTACCGTATAGGCTTTGGCACTATCCTTGTACCATCAATTAC
ACCATATTCAAAGTCAGGATGTACGTGGGAGGGGTGAGCACAGGCTGGAAG
CGGCCTGCAACTGGACGCGGGGCGAACGCTGTGATCTGGAAGACAGGGACAG
GTCCGAGCTCAGCCCATGTCTGTCTGCCACACAGTGGCAGTCTCTTCCGT
GTTCTTTACGACCTGCCAGCCTTGTCCACCGGCCTCATCCACCTCCACAGGA
ACATTGTGGACGTGCAGTACTTGTACGGGGTAGGGTCAAGCATCGCGTCTGG
GCCATTAAAGTGGGAGTACGTGCTTCTCCTGTTCTCCTGCTTGCAGACGCGCGC
GTCTGCTCCTGCTTGTGGATGATGTTACTCATATCCCAAGCGGAGGGCGGCTTTG
GAGAACCTCGTAATACTCAATGCAGCATCCCTGGCCGGGACGCACGGTCTTGT
GTCCTTCTCGTGTCTTCTGCTTTGCGTGGTATCTGAAGGGTAGGTGGGTGCC

FIGURE 22-1

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CGGAGCGGTCTACGCCTTCTACGGGAAGTGGGTCTTACTCTTATACCACATCTT
AGTGGGTACACCCAATCAAATCTGTAATTGTGATCCTACTGATGATTGGGGATGT
GGTAAAGGCCGATTACAGGGGGCCAAGAGTACTTGGGGAAAATAGACCTCTGTT
TTACAACAGTAGTACTAATCGTCATAGGTTTAAATCATAGCTAGGCGTGACCCAA
CTATAGTGCCACTGGTAACAATAATGGCAGCACTGAGGGTCACTGAACTGACC
CACCAGCCTGGAGTTGACATCGCTGTGGCGGTCACTGACTATAACCCTACTGAT
GGTTAGCTATGTGACAGATTATTTTAGATATAAAAAATGGTTACAGTGCATTCTC
AGCCTGGTATCTGCGGTGTTCTTGATAAGAAGCCTAATATACCTAGGTAGAATC
GAGATGCCAGAGGTAACCTATCCCAAACCTGGAGACCACTAACCTTAACTATTA
TATTTGATCTCAACAACAATTGTAACGAGGTGGAAGGTTGACGTGGCTGGCCTA
TTGTTGCAATGTGTGCCTATCTTATTGCTGGTCACAACCTTGTGGGCCGACTTCT
TAACCCTAATACTGATCCTGCCTACCTATGAATTGGTTAAATTATACTATCTGAA
AACTGTTAGGACTGATACAGAAAGAAGTTGGCTAGGGGGGATAGACTATACAA
GAGTTGACTCCATCTACGACGTTGATGAGAGTGGAGAGGGCGTATATCTTTTTTC
CATCAAGGCAGAAAGCACAGGGGAATTTTTCTATACTCTTGCCCCTTATCAAAG
CAACACTGATAAGTTGCGTCAGCAGTAAATGGCAGCTAATATACATGAGTTACT
TAACCTTTGGACTTTATGTACTACATGCACAGGAAAGTTATAGAAGAGATCTCAG
GAGGTACCAACATAATATCCAGGTTAGTGGCAGCACTCATAGAGCTGAACTGG
TCCATTGGAAGAAGAGGAGAGCAAAGGCTTAAAGAAGTTTTATCTATTGTCTGG
AAGGTTGAGAAACCTAATAATAAAACATAAAGGTAAGGAATGAGACCGTGGCTT
CTTGGTACGGGGAGGAGGAAGTCTACGGTATGCCAAAGATCATGACTATAATC
AAGGCCAGTACACTGAGTAAGAGCAGGCACTGCATAATATGCACTGTATGTGA
GGGCCGAGAGTGGAAAGGTGGCACCTGCCCAAATGTGGACGCCATGGGAAG
CCGATAACGTGTGGGATGTCGCTAGCAGATTTTGAAGAAAGACACTATAAAAG
AATCTTTATAAGGGAAGGCAACTTTGAGGGTATGTGCAGCCGATGCCAGGGAA
AGCATAGGAGGTTTGAAATGGACCGGGAACCTAAGAGTGCCAGATACTGTGCT
GAGTGTAATAGGCTGCATCCTGCTGAGGAAGGTGACTTTTGGGCAGAGTCGAG
CATGTTGGGCCTCAAAATCACCTACTTTGCGCTGATGGATGGAAAGGTGATATGA
TATCACAGAGTGGGCTGGATGCCAGCTGTGGGAATCTCCCGAGATACCCACA
GAGTCCCTTGTACATCTCATTTGGTTACGGATGCCTTTTCAGGCAGGAATACA
ATGGCTTTGTACAATATAACCGCTAGGGGGCAACTATTTCTGAGAACTTGCCCG
TACTGGCAACTAAAGTAAAAATGCTCATGGTAGGCAACCTTGGAGAAGAAATT
GGTAATCTGGAACATCTTGGGTGGATCCTAAGGGGGCCTGCCGTGTGTAAGAA
GATCACAGAGCACGAAAAATGCCACATTAATATACTGGATAAACTAACC GCATT
TTTCGGGATCATGCCAAGGGGGACTACACCCAGAGCCCCGGTGAGGTTCCCTA
CGAGCTTACTAAAAGTGAGGAGGGGTCTGGAGACTGCCTGGGCTTACACACAC
CAAGGCGGGATAAGTTTCAGTCGACCATGTAACCGCCGGAAAAAGATCTACTGGT
CTGTGACAGCATGGGACGAAGTAGAGTGGTTTGGCAAAGCAACAACAGGTTGA
CCGATGAGACAGAGTATGGCGTCAAGACTGACTCAGGGTGCCAGACGGTGC
CAGATGTTATGTGTTAAATCCAGAGGCCGTTAACATATCAGGATCCAAAGGGG
CAGTCGTTACCTCCAAAAGACAGGTGGAGAATTCACGTGTGTACCCGCATCA
GGCACACCGGCTTTCTTCGACCTAAAAAACTTGAAAGGATGGTCAGGCTTGCCT
ATATTTGAAGCCTCCAGCGGGAGGGTGTTGGCAGAGTCAAAGTAGGGAAGA
ATGAAGAGTCTAAACCTACAAAAATAATGAGTGGAAATCCAGACCGTCTCAAAAA
ACAGAGCAGACCTGACCGAGATGGTCAAGAAGATAACCAGCATGAACAGGGG
AGACTTCAAGCAGATTACTTTGGCAACAGGGGGCAGGCAAAACCACAGAAGTCC
CAAAAGCAGTTATAGAGGAGATAGGAAGACACAAGAGAGTATTAGTTCTTATA
CCATTAAGGGCAGCGGCAGAGTCAGTCTACCAGTATATGAGATTGAACACACC
AAGCATCTCTTTTAACCTAAGGATAGGGGACATGAAAGAGGGGGACATGGCAA
CCGGGATAACCTATGCATCATACGGGTACTTCTGCCAAATGCCTCAACCAAAGC
TCAGAGCTGCTATGGTAGAATACTCATACATATTCTTAGATGAATACCATTTGTGC
CACTCCTGAACAAGTGGCAATTATCGGGAAGATCCACAGATTTTTCAGAGAGTAT
AAGGGTTGTGCGCATGACTGCCACGCCAGCAGGGTCCGGTGACCACAACAGGT
CAAAAGCACCCAATAGAGGAATTCATAGCCCCCGAGGTAATGAAAGGGGAGG

FIGURE 22-2

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ATCTTGGTAGTCAGTTCCTTGATATAGCAGGGTTAAAAATACCAAGTGGATGAGA
TGAAAGGCAATATGTTGGTTTTTGTACCAACGAGAAAACATGGCAGTAGAGGTA
GCAAAGAAGCTAAAAGCTAAGGGCTATAACTCTGGATACTATTACAGTGGAGA
GGATCCAGCCAATCTGAGAGTTGTGACATCACAATCCCCCTATGTAATCGTGGC
TACAAATGCTATTGAATCAGGAGTGACACTACCAGATTTGGACACGGTTATAGA
CACGGGGTTGAAATGTGAAAAGAGGGTGAGGGTATCATCAAAGATACCCTTCA
TCGTAACAGGCCTTAAGAGGATGGCCGTGACTGTGGGTGAGCAGGCGCAGCG
TAGGGGCAGAGTAGGTAGAGTGAAACCCGGGAGGTATTATAGGAGCCAGGAA
ACAGCAACAGGGTCAAAGGACTACCACTATGACCTCTTGACAGGCACAAAGATA
CGGGATTGAGGATGGAATCAACGTGACGAAATCCTTTAGGGAGATGAATTACG
ATTGGAGCCTATACGAGGAGGACAGCCTACTAATAACCCAGCTGGAATACTA
AATAATCTACTCATCTCAGAAGACTTGCCAGCCGCTGTTAAGAACATAATGGCC
AGGACTGATCAGGAGCCAATCCAATTGCATACAAACAGCTATGAAGTCCA
GGTCCCGGTCTATTCCCAAAAATAAGGAATGGAGAAGTCACAGACACCTACG
AAAATTACTCGTTTCTAAATGCCAGAAAGTTAGGGGAGGATGTGCCCGTGTATA
TCTACGCTACTGAAGATGAGGATCTGGCAGTTGACCTCTTAGGGCTAGACTGG
CCTGATCCTGGGAACCAGCAGGTAGTGGAGACTGGTAAAGCACTGAAGCAAGT
GACCGGGTTGTCCTCGGCTGAAAATGCCCTACTAGTGGCTTTATTTGGGTATGT
GGGTTACCAGGCTCTCTCAAAGAGGCATGTCCCAATGATAACAGACATATATAC
CATCGAGGACCAGAGACTAGAAGACACCACCCACCTCCAGTATGCACCCAACG
CCATAAAAAACCGATGGGACAGAGACTGAACTGAAAGAAGTGGCGTCGGGTGA
CGTGGAAAAAATCATGGGAGCCATTTAGATTATGCAGCTGGGGGACTGGAGT
TTGTTAAATCCCAAGCAGAAAAGATAAAAAACAGCTCCTTTGTTTAAAGAAAACG
CAGAAGCCGCAAAAAGGGTATGTCCAAAAATTCATTGACTCATTAAATTGAAAATA
AAGAAGAAATAATCAGATATGGTTTGTGGGGAACACACACAGCACTATACAAA
AGCATAGCTGCAAGACTGGGGCATGAAACAGCGTTTGCCACACTAGTGTTAAA
GTGGCTAGCTTTTGGAGGGGAATCAGTGTGAGACCACGTCAAGCAGGCGGCA
GTTGATTTAGTGGTCTATTATGTGATGAATAAGCCTTCCTTCCAGGTGACTCC
GAGACACAGCAAGAAGGGAGGCGATTTCGTCGCAAGCCTGTTTCATCTCCGCACT
GGCAACCTACACATACAAAACCTTGAATTACCACAATCTCTCTAAAGTGGTGGGA
ACCAGCCCTGGCTTACCTCCCCTATGCTACCAGCGCATTAAAAATGTTACCCC
AACGCGGCTGGAGAGCGTGGTGATACTGAGCACCACGATATATAAACATACAC
TCTCTATAAGGAAGGGGAAGAGTGTGATGAGTTGCTGGGTACGGGATAAGTGC
AGCCATGGAATCCTGTCAAAAACCCAGTATCGGTAGGTATATCTGTGATGTT
GGGGGTAGGGGCAATCGCTGCGCACAACGCTATTGAGTCCAGTGAACAGAAA
AGGACCCTACTTATGAAGGTGTTTGTAAAGAACTTCTTGGATCAGGCTGCAACA
GATGAGCTGGTAAAAGAAAACCCAGAAAAAATTATAATGGCCTTATTTGAAGCA
GTCCAGACAATTGGTAACCCCTGAGACTAATATACCACCTGTATGGGGTTTAC
TACAAAGGTTGGGAGGCCAAGGAACTATCTGAGAGGACAGCAGGCAGAAACT
TATTCACATTGATAATGTTTGAAGCCTTCGAGTTATTAGGGATGGACTCACAAG
GGAAAATAAGGAACCTGTCCGGAATTACATTTTGGATTTGATATACGGCCTAC
ACAAGCAAATCAACAGAGGGCTGAAGAAAATGGTACTGGGGTGGGCCCTGC
ACCCTTTAGTTGTGACTGGACCCCTAGTGACGAGAGGATCAGATTGCCAACAG
ACAATATTTGAGGGTAGAAACCAGGTGCCCATGTGGCTATGAGATGAAAGCT
TTCAAAAATGTAGGTGGCAAACCTTACCAAAGTGGAGGAGAGCGGGCCTTTCCT
ATGTAGAAACAGACCTGGTAGGGGACCAGTCAACTACAGAGTCACCAAGTATT
ACGATGACAACCTCAGAGAGATAAAACCAGTAGCAAAGTTGGAAGGACAGGTA
GAGCACTACTACAAAGGGGTACAGCAAAAATTGACTACAGTAAAGGAAAAAT
GCTCTTGGCCACTGACAAGTGGGAGGTGGAACATGGTGTCTATAACCAGGTTAG
CTAAGAGATATACTGGGGTCCGGTTCAATGGTGCATACTTAGGTGACGAGCCC
AATCACCGTGCTCTAGTGGAGAGGGAGTGTGCAACTATAACCAAAAACACAGT
ACAGTTTCTAAAAATGAAGAAGGGGTGTGCGTTACCTATGACCTGACCATCTC
CAATCTGACCAGGCTCATCGAACTGTACACAGGAACAATCTTGAAGGAAGG
AAATACCCACCGCTACGGTCACCACATGGCTAGCTTACACCTTCGTGAATGAAG

FIGURE 22-3



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<p>(51) International Patent Classification ⁶ : A61K 39/29, 39/295, C12Q 1/70, C12N 7/01, C07H 21/02</p>	<p>A1</p>	<p>(11) International Publication Number: WO 99/55366 (43) International Publication Date: 4 November 1999 (04.11.99)</p>
<p>(21) International Application Number: PCT/US99/08850 (22) International Filing Date: 23 April 1999 (23.04.99) (30) Priority Data: 60/082,964 24 April 1998 (24.04.98) US (71) Applicant (for all designated States except US): WASHINGTON UNIVERSITY [US/US]; One Brookings Drive, St. Louis, MO 63130 (US). (72) Inventors; and (75) Inventors/Applicants (for US only): RICE, Charles, M. [US/US]; 7316 Colgate Avenue, University City, MO 63130 (US). FROLOV, Ilya [RU/US]; 200 Tanglewood Drive, St. Louis, MO 63129 (US). McBRIDE, M., Scott [US/US]; 2807 Mickelson Pkwy. #205, Madison, WI 53711 (US). LEE, Young-min [KR/US]; 5530 Genesta Walk, St. Louis, MO 63123 (US). AGAPOV, Eugene, V. [RU/US]; 7515 Cromwell Drive, Apt. 2NE, St. Louis, MO 63105 (US). MYERS, Tina, M. [US/US]; 8141 Briarhaven Trail, Apt.102, St. Louis, MO 63123 (US).</p>		<p>(74) Agents: HOLLAND, Donald, R. et al.; Howell & Haferkamp, L.C., Suite 1400, 7733 Forsyth Boulevard, St. Louis, MO 63105-1817 (US). (81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG). Published <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i></p>
<p>(54) Title: CHIMERAS OF HEPATITIS C VIRUS AND BOVINE VIRAL DIARRHEA VIRUS (57) Abstract Disclosed is a polynucleotide comprising a chimeric viral RNA which contains: a 5' nontranslated region (5' NTR), an open reading frame (ORF) region, and a 3' nontranslated region (3' NTR) wherein at least one of said regions is chimeric. The chimeric region comprises a first nucleotide sequence from a pestivirus in operable linkage with a heterologous nucleotide sequence. The chimeric viral RNA is replication-competent. Preferably the pestivirus sequence is from a bovine viral diarrhea virus and the heterologous nucleotide sequence is from a hepatitis C virus. Also disclosed are a method for identifying compounds having antiviral activity against hepatitis C virus, a genetically-engineered chimeric RNA virus and a vaccine against bovine viral diarrhea virus.</p>		

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US99/08850

Box I Observations where certain claims were found unsearchable (Continuation of Item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 9
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

CLAIM 9 RECITES "SEQ ID NO:X" WHICH EXPRESSION IS NOT UNDERSTOOD.

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐

The additional search fees were accompanied by the applicant's protest.

☐

No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US99/08850

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	LU et al. Poliovirus chimeras replicating under the translational control of genetic elements of hepatitis C virus reveal unusual properties of the internal ribosomal entry site of hepatitis C virus. Proc. Natl. Acad. Sci. USA. 20 February 1996, Vol. 93, No. 4, pages 1412-1417, see entire document.	1-8, 10-21
Y	VASSILEV et al. Authentic and chimeric full-length genomic cDNA clones of bovine viral diarrhea virus that yield infectious transcripts. J. Virol. January 1997, Vol. 71, No. 1, pages 471-478, see entire document.	1-8, 10-21
Y	VENUGOPAL et al. Towards a new generation of flavivirus vaccines. Vaccines. 1994, Vol. 12, No. 11, pages 966-975, see entire document.	1-8, 10-21

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US99/08850

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : A61K 39/29, 39/295; C12Q 1/70; C12N 7/01; C07H 21/02

US CL : 424/218.1, 228.1; 435/5, 235.1; 536/23.72

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 424/218.1, 228.1; 435/5, 235.1; 536/23.72

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS; Derwent/WEST; DIALOG

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X,P	FROLOV et al. cis-acting RNA elements required for replication of bovine viral diarrhea virus-hepatitis C virus 5' nontranslated region chimeras. RNA. November 1998, Vol. 4, pages 1418-1435, see entire document.	1-8, 10-21
Y,P	MALET et al. Yellow fever 5' noncoding region as a potential element to improve hepatitis C virus production through modification of translational control. Biochem. Biophys. Res. Commun. 18 December 1998, Vol. 253, No. 2, pages 257-264, see entire document.	1-8, 10-21

☒ Further documents are listed in the continuation of Box C.☐ See patent family annex.

* Special categories of cited documents:	*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
A document defining the general state of the art which is not considered to be of particular relevance	*X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
E earlier document published on or after the international filing date	*Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
L document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	*Z* document member of the same patent family
O document referring to an oral disclosure, use, exhibition or other means	
P document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

19 JULY 1999

Date of mailing of the international search report

10 SEP 1999

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DONNA C. WORTMAN

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CACTGTTTGAGGAATTGTTGCTACGGTGCCACCTGCAACTAAGAGCAATAAG
GGGCACATGGCATCAGCTTACCAATTGGCACAGGGTAACTGGGAGCCCCCTCGG
TTGCGGGGTGCACCTAGGTACAATACCAGCCAGAAGGGTGAAGATACACCCAT
ATGAAGCTTACCTGAAGTTGAAAGATTTTCATAGAAGAAGAAGAGAAGAAACCT
AGGGTTAAGGATACAGTAATAAGAGAGCACAAACAATGGATACTTAAAAAAT
AAGGTTTCAAGGAAACCTCAACACCAAGAAAATGCTCAACCCTGGGAAACTATC
TGAACAGTTGGACAGGGAGGGGCGCAAGAGGAACATCTACAACCACCAGATT
GGTACTATAATGTCAAGTGCAGGCATAAGGCTGGAGAAATTGCCAATAGTGAG
GGCCCAAACCGACACCAAACCTTTCATGAGGCAATAAGAGATAAGATAGACA
AGAGTGAAAACCGGCCAAAATCCAGAATTGCACAACAATTTGTTGGAGATTTTCC
ACACGATAGCCCAACCCACCCTGAAACACACCTACGGTGAGGTGACGTGGGAG
CAACTTGAGGCGGGGATAAATAGAAAGGGGGCAGCAGGCTTCTGGAGAAGA
AGAACATCGGAGAAGTATTGGATTGAGAAAAGCACCTGGTAGAACAATTGGTC
AGGGATCTGAAGGCCGGGAGAAAGATAAAATATTATGAAACTGCAATACCAAA
AAATGAGAAGAGAGATGTCAGTGATGACTGGCAGGCAGGGGACCTGGTGGTT
GAGAAGAGGCCAAGAGTTATCCAATACCCTGAAGCCAAGACAAGGCTAGCCAT
CACTAAGGTCATGTATAACTGGGTGAAACAGCAGCCCGTTGTGATTCCAGGAT
ATGAAGGAAAGACCCCTTGTTCACATCTTTGATAAAGTGAGAAAGGAATGG
GACTCGTTCAATGAGCCAGTGGCCGTAAGTTTTGACACCAAAGCCTGGGACAC
TCAAGTGAAGTAAAGGATCTGCAACTTATTGGAGAAATCCAGAAATATTACTA
TAAGAAGGAGTGGCACAAGTTCATTGACACCATCACCGACCACATGACAGAAG
TACCAGTTATAACAGCAGATGGTGAAGTATATATAAGAAATGGGCAGAGAGGG
AGCGGCCAGCCAGACACAAGTGTGGCAACAGCATGTTAAATGTCCTGACAAT
GATGTAAGCCTTCTGCGAAAGCACAGGGGTACCGTACAAGAGTTTCAACAGGG
TGGCAAGGATCCACGTCTGTGGGGATGATGGCTTCTTAATAACTGAAAAAGGG
TTAGGGCTGAAATTTGCTAACAAAGGGATGCAGATTCTTCATGAAGCAGGCAA
ACCTCAGAAGATAACGGAAGGGGAAAAGATGAAAGTTGCCTATAGATTTGAGG
ATATAGAGTTCTGTTCTCATACCCAGTCCCTGTTAGGTGGTCCGACAACACCA
GTAGTCACATGGCCGGGAGAGACACCGCTGTGATACTATCAAAGATGGCAACA
AGATTGGATTCAAGTGGAGAGAGGGGTACCACAGCATATGAAAAAGCGGTAG
CCTTCAGTTTTCTTGCTGATGTATTCCTGGAACCCGCTTGTAGGAGGATTTGCCT
GTTGGTCTTTTCGCAACAGCCAGAGACAGACCCATCAAAACATGCCACTTATTA
TTACAAAGGTGATCCAATAGGGGCCTATAAAGATGTAATAGGTCGGAATCTAA
GTGAACTGAAGAGAACAGGCTTTGAGAAATTGGCAAATCTAAACCTAAGCCTG
TCCACGTTGGGGATCTGGACTAAGCACACAAGCAAAAGAATAATTCAGGACTG
TGTTGCCATTGGGAAAGAAGAGGGCAACTGGCTAGTTAACGCCGACAGGCTGA
TATCCAGCAAAACTGGCCACTTATACATACCTGATAAAGGCTTTACATTACAAG
GAAAGCATTATGAGCAACTGCAGCTAAGAACAGAGACAAACCCGGTCATGGGG
GTTGGGACTGAGAGATACAAGTTAGGTCCCATAGTCAATCTGCTGCTGAGAAG
GTTGAAAATTCTGCTCATGACGGCCGTCGGCGTCAGCAGCTGAgacaaaatgtatatattgt
aaataaattaatccatgtacatagttatatataatagttgggaccgtccacctcaagaagacgacacgccaacacgcacagctaaac
agtagtcaagattatctacctcaagataacactacattaatgcacacagcacttagctgtataggatagcggcgacgtctatagttggac
tagggaagaccttaacagccccc

FIGURE 26-6

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ACTGAAGATGAGGATCTGGCAGTTGACCTCTTAGGGCTAGACTGGCCTGATCC
TGGGAACCAAGCAGGTAGTGGAGACTGGTAAAGCACTGAAGCAAGTGACCGGG
TTGTCCTCGGCTGAAAATGCCCTACTAGTGGCTTTATTTGGGTATGTGGGTAC
CAGGCTCTCTCAAAGAGGCATGTCCCAATGATAACAGACATATATACCATCGAG
GACCAGAGACTAGAAGACACCACCCACCTCCAGTATGCACCCAACGCCATAAA
AACCGATGGGACAGAGACTGAACTGAAAGAACTGGCGTCGGGTGACGTGGAA
AAAATCATGGGAGCCATTTTCAGATTATGCAGCTGGGGGACTGGAGTTTGTTAA
ATCCCAAGCAGAAAAGATAAAAAACAGCTCCTTTGTTTAAAGAAAACGCAGAAGC
CGCAAAAGGGTATGTCCAAAAATTCATTGACTCATTAATTGAAAATAAAGAAGA
AATAATCAGATATGGTTTGTGGGGAACACACACAGCACTATACAAAAGCATAGC
TGCAAGACTGGGGCATGAAACAGCGTTTGCCCACTAGTGTTAAAGTGGCTAG
CTTTTGGAGGGGAATCAGTGTGAGACACGTCAAGCAGGCGGCAGTTGATTTA
GTGGTCTATTATGTGATGAATAAGCCTTCCTTCCCAGGTGACTCCGAGACACAG
CAAGAAGGGAGGCGATTTCGTGCAAGCCTGTTTCATCTCCGCACTGGCAACCTA
CACATACAAAACCTTGAATTACCACAATCTCTCTAAAGTGGTGGAAACAGCCCT
GGCTTACCTCCCCTATGCTACCAGCGCATTAAAAATGTTTACCCCCAACGCGGT
GGAGAGCGTGGTGATACTGAGCACCACGATATATAAAACATACCTCTCTATAAG
GAAGGGGAAGAGTGATGGATTGCTGGGTACGGGGATAAGTGCAGCCATGGAA
ATCCTGTCACAAAACCCAGTATCGGTAGGTATATCTGTGATGTTGGGGGTAGG
GGCAATCGCTGCGCACAAACGCTATTGAGTCCAGTGAACAGAAAAGGACCCTAC
TTATGAAGGTGTTTGTAAAGAACTTCTTGGATCAGGCTGCAACAGATGAGCTGG
TAAAAGAAAACCCAGAAAAAATTATAATGGCCTTATTTGAAGCAGTCCAGACAA
TTGGTAACCCCTGAGACTAATATACCACTGTATGGGGTTTACTACAAAGGTT
GGGAGGCCAAGGAACTATCTGAGAGGACAGCAGGCAGAACTTATTCACATTG
ATAATGTTTGAAGCCTTCGAGTTATTAGGGATGGACTCACAAGGGAAAATAAG
GAACCTGTCCGGAATTACATTTTGGATTGATATACGGCCTACACAAGCAAAT
CAACAGAGGGCTGAAGAAAATGGTACTGGGGTGGGCCCCCTGCACCCTTTAGTT
GTGACTGGACCCCTAGTGACGAGAGGATCAGATTGCCAACAGACAACCTATTTG
AGGGTAGAAACCAAGGTGCCCATGTGGCTATGAGATGAAAGCTTTCAAAAATGT
AGGTGGCAAACCTTACCAAAGTGGAGGAGAGCGGGCCTTTCCTATGTAGAAACA
GACCTGGTAGGGGACCAGTCAACTACAGAGTACCAAGTATTACGATGACAAAC
CTCAGAGAGATAAAACCAAGTAGCAAAAGTTGGAAGGACAGGTAGGCACTACTA
CAAAGGGGTACAGCAAAAATTGACTACAGTAAAGGAAAAAATGCTCTTGGCCA
CTGACAAGTGGGAGGTGGAACATGGTGTGATAACCAAGGTAGCTAAGAGATAT
ACTGGGGTTCGGGTTCAATGGTGCATACTTAGGTGACGAGCCCAATCACCGTGC
TCTAGTGGAGAGGGACTGTGCAACTATAACCAAAAACACAGTACAGTTTCTAAA
AATGAAGAAGGGGTGTGCGTTCACCTATGACCTGACCATCTCCAATCTGACCA
GGCTCATCGAACTAGTACACAGGAACAATCTTGAAGAGAAGGAAATACCCACC
GCTACGGTCACCAATGGCTAGCTTACACCTTCGTGAATGAAGACGTAGGGAC
TATAAAACCAAGTACTAGGAGAGAGAGTAATCCCCGACCCTGTAGTTGATATCAA
TTTACAACCAAGGTGCAAGTGGACACGTGACAGGTTGGGATCACAATAATTG
GAAGGGAAACCCCTGATGACAACGGGAGTGACACCTGTCTTGGAAAAAGTAGA
GCCTGACGCCAGCGACAACCAAACTCGGTGAAGATCGGGTTGGATGAGGGT
AATTACCCAGGGCCTGGAATACAGACACATACTAACAGAAGAAATACACAA
CAGGGATGCGAGGGCCCTTCATCATGATCCTGGGCTCAAGGAATTCCATATCAA
ATAGGGCAAAGACTGCTAGAAATATAAATCTGTACACAGGAATGACCCCAAGG
GAAATACGAGACTTGATGGCTGCAGGGCGCATGTTAGTAGTAGCACTGAGGGA
TGTCGACCCCTGAGCTGTCTGAAATGGTTCGATTTCAAGGGGACTTTTTAGATAG
GGAGGCCCTGGAGGCTCTAAGTCTCGGGCAACCTAAACCGAAGCAGGTTACCA
AGGAAGCTGTTAGGAATTTGATAGAACAAGAAAAAGATGTGGAGATCCCTAAC
TGGTTTGCATCAGATGACCCAGTATTTCTGGAAGTGGCCTTAAAAAATGATAAG
TACTACTTAGTAGGAGATGTTGGAGAGGTAAGATCAAGCTAAAGCACTTGG
GCCACGGATCAGACAAGAATTATAAAGGAGGTAGGCTCAAGGACGTATGCCA
TGAAGCTATCTAGCTGGTTCCTCAAGGCATCAAACAAACAGATGAGTTTAACTC

FIGURE 26-5

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ACTGATAAGTTGCGTCAGCAGTAAATGGCAGCTAATATACATGAGTTACTTAACTTTGGACTTTATGTACTACATGCACAGGAAAGTTATAGAAGAGATCTCAGGAGGTACCAACATAATATCCAGGTTAGTGGCAGCACTCATAGAGCTGAACTGGTCCATGGAAGAAGAGGAGAGCAAAGGCTTAAAGAAGTTTTATCTATTGTCTGGAAGGTGAGAAACCTAATAATAAAACATAAGGTAAGGAATGAGACCGTGGCTTCTTGGTACGGGGAGGAGGAAGTCTACGGTATGCCAAAGATCATGACTATAATCAAGGCCAGTACACTGAGTAAGAGCAGGCACTGCATAATATGCACTGTATGTGAGGGCCGAGAGTGGAAGGTGGCACCTGCCCAAATGTGGACGCCATGGGAAGCCGATAACGTGTGGGATGTCGCTAGCAGATTTTGAAGAAAGACACTATAAAAGAATCTTTATAAGGGAAGGCAACTTTGAGGGTATGTGCAGCCGATGCCAGGGAAGCATAGGAGTTTTGAAATGGACCGGGAACCTAAGAGTGCCAGATACTGTGCTGAGTGTAAATAGGCTGCATCCTGCTGAGGAAGGTGACTTTTGGGCAGAGTCGAGCATGTTGGGCTCAAATCACCTACTTTGCGCTGATGGATGGAAGGTGTATGATATCACAGAGTGGGCTGGATGCCAGCGTGTGGGAATCTCCCCAGATACCCACAGAGTCCCTTGTCACATCTCATTGTTTACGGATGCCTTTCAGGCAGGAATACAATGGCTTGGTACAATATACCGCTAGGGGGCAACTATTTCTGAGAACTTGCCCGTACTGGCAACTAAAGTAAAAATGCTCATGGTAGGCAACCTTGAGAGAAGAAATTGGTAATCTGGAACATCTTGGGTGGATCCTAAGGGGGCCTGCCGTGTGTAAGAAGATCACAGAGCAGAAAAATGCCACATTAATATACTGGATAAACTAACCCGATTTTTCGGGATCATGCCAAGGGGGACTACACCCAGAGCCCCGGTGAGGTTCCCTACGAGCTTACTAAAAGTGAGGAGGGGTCTGGAGACTGGCTGGGCTTACACACACCAAGGCAGGATAAGTTCAGTCGACCATGTAACCGCCGGAAGATCTACTGGTCTGTGACAGCATGGGACGAAGTACAGTGGTTTGCCAAAGCAACAACAGGTTGACCGATGAGACAGAGTATGGCGTCAAGACTGACTCAGGGTGCCAGACGGTGCCAGATGTTATGTGTTAAATCCAGAGGCCGTTAACATATCAGGATCCAAAGGGGCAGTCGTTCACTCCAAAAGACAGGTGGAGAATTCACGTGTGTCACCGCATCAGGCACACCGGCTTTCTTCGACCTAAAAAACTTGAAAGGATGGTCAGGCTTGCCCTATATTTGAAGCTCCAGCGGGAGGGTGGTTGGCAGAGTCAAAGTAGGGAAGAATGAAGAGTCTAAACCTACAAAAATAATGAGTGGAAATCCAGACCGTCTCAAAAAACACAGCAGACCTGACCGAGATGGTCAAGAAGATAAACCAGCATGAACAGGGGAGACTTCAAGCAGATTACTTTGGCAACAGGGGCAGGCAAAACCACAGAACTCCCAAAAGCAGTTATAGAGGAGATAGGAAGACACAAGAGAGTATTAGTTCTTATACCATTAAGGCGACGGCAGAGTCAGTCTACCAGTATATGAGATTGAAACACCCAAGCATCTCTTTTAACCTAAGGATAGGGGACATGAAAGAGGGGGACATGGCAACCGGGGATAACCTATGCATCATACGGGTACTTCTGCCAAATGCCTCAACCAAGGCTCAGAGCTGCTATGGTAGAATACTCATACATATTCTTAGATGAATACCATTGTGCCACTCCTGAACAACCTGGCAATTATCGGGAAGATCCACAGATTTTCAGAGAGTATAAGGGTGTGCGCCATGACTGCCACGCCAGCAGGGTCGGTGACCACAACAGGTCAAAGCACCAATAGAGGAATTCATAGCCCCGAGGTAATGAAAGGGGAGGATCTTGGTAGTCAGTTCCTTGATATAGCAGGGTTAAAAATACCAGTGGATGAGATGAAAGGCAATATGTTGGTTTTTTGTACCAACGAGAAACATGGCAGTAGAGGTAGCAAAGAAGCTAAAAGCTAAGGGCTATAACTCTGGATACTATTACAGTGGAGAGGATCCAGCCAATCTGAGAGTTGTGACATCACAATCCCCCTATGTAATCGTGGCTACAAATGCTATTGAATCAGGAGTGACACTACCAGATTTGGACACGGTTATAGACACGGGGTTGAAATGTGAAAAGAGGGTGAGGGTATCATCAAAGATACCCCTTCATCGTAAAGGCTTAAGAGGATGGCCGTGACTGTGGGTGAGCAGGCGCAGCGTAGGGGCAGAGTAGGTAGAGTGAAACCCGGGAGGTATTATAGGAGCCAGGAAACAGCACAGGGTCAAAGGACTACCACTATGACCTCTTGACGGCACAAGATACGGGATGAGGATGGAATCAACGTGACGAAATCCTTTAGGGAGATGAATTACGATTGGAGCCTATACGAGGAGGACAGCCTACTAATAACCCAGCTGGAAATACTAAATAATCTACTCATCTCAGAAGACTTGCCAGCCGCTGTTAAGAACATAATGGCCAGGACTGATCACCCAGAGCCAATCCAACCTGCATACAACAGCTATGAAGTCCAGGTCCCGGTCTGTTCCCAAAAATAAGGAATGGAGAAGTCACAGACACCTACGAAAATTACTCGTTTCTAAATGCCAGAAAGTTAGGGGAGGATGTGCCCGTGTATATCTACGCT

FIGURE 26-4

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TCCCGCCAAGCAGAGGTTATCACCCCTGCTGTCCAGACCAACTGGCAGAAACT
 CGAGGTCTTCTGGGCGAAGCACATGTGGAATTTTCATCAGTGGGATACAATACTT
 GGCGGGCCTGTCAACGCTGCCTGGTAACCCCGCCATTGCTTCATTGATGGCTTT
 TACAGCTGCCGTCACCAGCCCACTAACCCTGGCCAAACCCTCCTCTTCAACAT
 ATTGGGGGGGTGGGTGGCTGCCAGCTCGCCGCCCCCGGTGCCGCTACCGCC
 TTTGTGGGCGCTGGCTTAGCTGGCGCCGCCATCGGCAGCGTTGGACTGGGGA
 AGGTCTCTCGTGACATTCTTGACGGGTATGGCGCGGGCGTGGCGGGAGCTCT
 TGTAGCCTTCAAGATCATGAGCGGTGAGGTCCCCTCCACGGAGGACCTGGTCA
 ATCTGCTGCCCCGCCATCCTCTCGCCTGGAGCCCTTGTAGTCGGTGTGGTCTGC
 GCAGCAATACTGCGCCGGCACGTTGGCCCGGGCGAGGGGCGAGTGAATGGA
 TGAACCGGCTAATAGCCTTCGCCTCCCGGGGAACCATGTTTCCCCCACGCAC
 TACGTGCCGGAGAGCGATGCAGCCGCCCGCGTCACTGCCATACTCAGCAGCCT
 CACTGTAACCCAGCTCCTGATcgCTAGaccatgggtaccgagCGTTACTGGCCGAAGCC
 GCTTGAATAAAGGCCGGTGTGCGTTTGTCTATATGTTATTTTCCACCATATTGCC
 GTCTTTTGGCAATGTGAGGGCCCGGAAACCTGGCCCTGTCTTCTTGACGAGCA
 TTCCTAGGGGTCTTTCCCTCTCGCCAAAGGAATGCAAGGTCTGTTGAATGTGC
 TGAAGGAAGCAGTTCCTCTGGAAGCTTCTTGAAGACAAACAACGTCTGTAGCG
 ACCCTTTGCAGGCAGCGGAACCCCCACCTGGCGACAGGTGCCTCTGCGGCCA
 AAAGCCACGTGTATAAGATACACCTGCAAAGGCGGCACAACCCAGTGCCACG
 TTGTGAGTTGGATAGTTGTGGAAAGAGTCAAATGGCTCTCCTCAAGCGTATTCA
 ACAAGGGGCTGAAGGATGCCCAGAAGGTACCCATTGTATGGGATCTGATCTG
 GGGCTCGGTGCACATGCTTTACATGTGTTTAGTCGAGGTTAAAAAACGTCTAG
 GCCCCCGAACCACGGGGACGTGGTTTTCTTTGAAAAACACGATGATAATAT
 GGAGTTGATCACAATGAACTTTTATACAAAACATACAAACAAAAACCCGTCGG
 GGTGGAGGAACCTGTTTATGATCAGGCAGGTGATCCCTTATTTGGTGAAAGGG
 GAGCAGTCCACCCTCAATCGACGCTAAAGCTCCACACAAGAGAGGGGAACCG
 GATGTTCCAACCAACTTGGCATCCTTACCAAAAAGAGGTGACTGCAGGTGCGG
 TAATAGCAGAGGACCTGTGAGCGGGATCTACCTGAAGCCAGGGCCACTATTTT
 ACCAGGACTATAAAGGTCCCGTCTATCACAGGGCCCCGCTGGAGCTCTTTGAG
 GAGGGATCCATGTGTGAAACGACTAAACGGATAGGGAGAGTAACTGGAAGTG
 ACGGAAAGCTGTACCACATTTATGTGTATAGATGGATGTATAATAATAAAAA
 GTGCCACGAGAAGTTACCAAAGGGTGTTTCAAGGTGGGTCCATAATAGGCTTGAC
 TGCCCTCTATGGGTACAAAGTTGCTCAGACACGAAAGAAGAGGGGAGCAACAaag
 ctTGCAATTGTTGGCGTGGGCAATAATAGCTATAGTTTTGTTTCAAGTTACAATGGG
 AGAAAACATAACACAGTGGAACTgagTGGTTTGACCTGGAGGTGACTGACCAT
 CACCGGGATTACTTCGCTGAGTCCATATTAGTGGTGGTAGTAGCCCTCTTGGGT
 GGCAGATATGTACTTTGGTTACTGGTTACATACATGGTCTTATCAGAACAGAAG
 GCCTTAGGGATTAGTATGGATCAGGGGAAGTGGTGATGATGGGCAACTTGCT
 AACCATAACAATATTGAAGTGGTGACATACTTCTTGCTGCTGTACCTACTGCT
 GAGGGAGGAGAGCGTAAAGAAGTGGGTCTTACTCTTATACCACATCTTAGTGG
 TACACCCAATCAAATCTGTAATTGTGATCCTACTGATGATTGGGGATGTGGTAA
 AGGCCGATTACAGGGGGCCAAGAGTACTTGGGGAAAATAGACCTCTGTTTTACA
 ACAGTAGTACTAATCGTCATAGGTTTAAATCATAGCTAGGCGTGACCCAACATA
 GTGCCACTGGTAACAATAATGGCAGCACTGAGGGTCACTGAAGTACCCACCA
 GCCTGGAGTTGACATCGCTGTGGCGGTCTGACTATAACCTACTGATGGTTA
 GCTATGTGACAGATTATTTTAGATATAAAAAATGGTTACAGTGCATTCTCAGCCT
 GGTATCTGGGGTGTCTTGATAAGAAGCCTAATATACCTAGGTAGAATCGAGAT
 GCCAGAGGTAACATACTCCAAACTGGAGACCACTAACTTTAATACTATTATTTG
 ATCTCAACAACAATTGTAACGAGGTGGAAGGTTGACGTGGCTGGCCTATTGTT
 GCAATGTGTGCCTATCTTATTGCTGGTCACAACCTTGTGGGCCGACTTCTTAAC
 CCTAATACTGATCCTGCCTACCTATGAATTGGTTAAATTATACTATCTGAAAAC
 GTTAGGACTGATATAGAAAGAAGTTGGCTAGGGGGGATAGACTATACAAGAGT
 TGAATCCATCTACGACGTTGATGAGAGTGGAGAGGGCGTATATCTTTTCCATC
 AAGGCAGAAAGCACAGGGGAATTTTTCTATACTCTTGCCCTTATCAAAGCAAC

FIGURE 26-3

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CGGAGCGGTCTACGCCTTCTACGGGATGTGGCCTCTCCTCCTGCTCCTGCTGG
CGTTGCCTCAGCGGGCATACGCACTGGACACGGAGGTGGCCGCGTCGTGTGG
CGGCGTTGTTCTTGTGCGGTTAATGGCGCTGACTCTGTGCGCCATATTACAAGCG
CTACATCAGCTGGTGCATGTGGTGGCTTCAGTATTTTCTGACCAGAGTAGAAGC
GCAACTGCACGTGTGGGTCCCCCCTCAACGTCCGGGGGGGGCGCGATGCC
GTCATCTTACTCATGTGTGTTGTACACCCGACTCTGGTATTTGACATACCAAAC
TACTCCTGGCCATCTTCGGACCCCTTTGGATTCTTCAAGCCAGTTTGCTTAAAGT
CCCCTACTTCGTGCGCGTTCAAGGCCTTCTCCGGATCTGCGCGCTAGCGCGGA
AGATAGCCGGAGGTCATTACGTGCAAATGGCCATCATCAAGTTAGGGGCGCTT
ACTGGCACCTATGTGTATAACCATCTCACCCCTCTTCGAGACTGGGCGCACAAAC
GGCCTGCGAGATCTGGCCGTGGCTGTGAACCAAGTCGTCTTCTCCGAATGGA
GACCAAGCTCATCACGTGGGGGGCAGATACCGCCGCGTGCGGTGACATCATC
AACGGCTTGCCCGTCTCTGCCCGTAGGGGCCAGGAGATACTGCTTGGGCCAGC
CGACGGAATGGTCTCCAAGGGGTGGAGGTTGCTGGCGCCCATCACGGCGTAC
GCCCAGCAGACGAGAGGCCTCCTAGGGTGTATAATCACCAGCCTGACTGGCCG
GGACAAAAACCAAGTGGAGGGTGAGGTCCAGATCGTGTCAACTGCTACCCAAA
CCTTCCTGGCAACGTGCATCAATGGGGTATGCTGGACTGTCTACCACGGGGCC
GGAACGAGGACCATCGCATCACCAAGGGTCCTGTCTATCCAGATGTATACAA
TGTGGACCAAGACCTTGTGGGCTGGCCCGCTCCTCAAGGTTCCCGCTCATTGA
CACCTGCGACCTGCGGCTCCTCGGACCTTTACCTGGTCACGAGGCACGCCGAT
GTCAATCCCGTGCGCCGGCAGGTGATAGCAGGGGTAGCCTGCTTTCGCCCCG
GCCATTTCTACTTGAAAGGCTCCTCGGGGGTCCGCTGTTGTGCCCCGCGG
GACACGCCGTGGGCCTATTCAAGGGCCGCGGTGTGCACCCGTGGAGTGCTAA
GGCGGTGGACTTTATCCCTGTGGAGAACCTAGAGACAACCATGAGATCCCCGG
TGTTACGGACAACCTCCTCTCCACCAGCAGTGCCCCAGAGCTTCCAGGTGGCC
CACCTGCATGCTCCCACCGGCAGCGGTAAGAGCACCAAGGTCCCGGCTGCGTA
CGCAGCCCAGGGCTACAAGGTGTTGGTGTCAACCCCTCTGTTGCTGCAACGC
TGGGCTTTGGTGCTTACATGTCCAAGGCCCATGGGGTTGATCCTAATATCAGGA
CCGGGGTGAGAACAAATTACCACTGGCAGCCCCATCACGTACTCCACCTACGGC
AAGTTCCTTGCCGACGGCGGGTGCTCAGGAGGTGCTTATGACATAATAATTTGT
GACGAGTGCCACTCCACGGATGCCACATCCATCTTGGGCATCGGCACTGTCT
TGACCAAGCAGAGACTGCGGGGGCAGAGACTGGTTGTGCTCGCCACTGCTACC
CCTCCGGGCTCCGTCACTGTGTCCCATCCTAACATCGAGGAGGTTGCTCTGTCC
ACCACCGGAGAGATCCCCTTTTACGGCAAGGCTATCCCCCTCGAGGTGATCAA
GGGGGGAAGACATCTCATCTTCTGCCACTCAAAGAAGAAGTGCGACGAGCTCG
CCGCGAAGCTGGTCGCATTGGGCATCAATGCCGTGGCCTACTACCGCGGTCTT
GACGTGTCTGTATCCCGACCGAGCGCGATGTTGTGTCGTGTCGACCGATGC
TCTCATGACTGGCTTTACCGGCGACTTCGACTCTGTGATAGACTGCAACACGTG
TGTCACTCAGACAGTCGATTTACGCCTTGACCCTACCTTTACCATTGAGACAAC
CACGTCCCCCAGGATGCTGTCTCCAGGACTCAACGCCGGGGCAGGACTGGC
AGGGGGAAGCCAGGCATCTACAGATTTGTGGCACCGGGGGAGCGCCCTCCG
GCATGTTGACTCGTCCGTCTCTGTGAGTGCTATGACGCGGGCTGTGCTTGG
TATGAGCTCACGCCCCGCGAGACTACAGTTAGGCTACGAGCGTACATGAACAC
CCCGGGGCTTCCCGTGTGCCAGGACCATCTTGAATTTTGGGAGGGCGTCTTTA
CGGGCCTCACTCATATAGATGCCCACTTTCTATCCCAGACAAAGCAGAGTGGG
GAGAACTTTCCTTACCTGGTAGCGTACCAAGCCACCGTGTGCGCTAGGGCTCA
AGCCCCTCCCCCATCGTGGGACCAGATGTGGAAGTGTTTGATCCGCCTTAAAC
CCACCCTCCATGGGCCAACACCCCTGCTATACAGACTGGGCGCTGTTAGAAT
GAAGTACCCTGACGCACCCAATACCAAAATACATCATGACATGCATGTCCGCC
GACCTGGAGGTCGTACGAGCACCTGGGTGCTCGTTGGCGGCGTCTGGCTG
CTCTGGCCGCGTATTGCTGTCAACAGGCTGCGTGGTCATAGTGGGCGAGGATT
GTCTTGTCCGGGAAGCCGGCAATTATACCTGACAGGGAGGTTCTCTACCAGGA
GTTTCGATGAGATGGAAGAGTGCTCTCAGCACTTACCGTACATCGAGCAAGGGA
TGATGCTCGCTGAGCAGTTCAAGCAGAAGGCCCTCGGCCTCCTGCAGACCGCG

FIGURE 26-2

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Gtatac gagaattagaaaaggcactcgtatacgtattgggcaataaaaaataataattaggcctaggtacatggcacgtgccagccccct
gatggggcgacactccaccatgaatcactcccctgtgaggaactactgtcttcacgcagaaagcgtctagccatggcgtagtatgag
tgtcgtgcagcctccaggacccccctcccgaggagagccatagtggtctgcggaaccggtgagtagaccggaattgccaggacgac
cggtctcttcttgataaaccgctcaatgcctggagatttggcggtgccccgcaagactgtagccgagtagtgggtcgcgaa
aggccttggtagtgcctgataagggtcctgagtgagtgccccgggaggtctcgtagaccgtgcaccATGAGCACGAATC
CTAAACCTCAAAGAAAAACCAACGTAACACCAACCGTCGCCCCACAGGACGTC
AAGTTCCCGGGTGGCGGTGAGATCGTTGGTGGAGTTTACTTGTGTCGCGCGCAG
GGGCCCTAGATTGGGTGTGCGCGCGACGAGGAAGACTTCCGAGCGGTCCGAA
CCTCGAGGTAGACGTCAGCCTATCCCCAAGGCACGTCGGCCCCGAGGGCAGGA
CCTGGGCTCAGCCCCGGGTACCCCTTGGCCCCCTCTATGGCAATGAGGGTTGCGGG
TGGGCGGGATGGCTCCTGTCTCCCCGTGGCTCTCGGCCCTAGCTGGGGCCCCAC
AGACCCCCGGCGTAGGTGCGCGCAATTTGGGTAAGGTCATCGATACCCCTTACGT
GCGGCTTCGCGACCTCATGGGGTACATACCGCTCGTCGGCGCCCCCTCTTGA
GGCGCTGCCAGGGCCCTGGCGCATGGCGTCCGGGTTCTGGAAGACGGCGTGA
ACTATGCAACAGGGAACCTTCTGTTGCTCTTTCTCTATCTTCTTCTGCCCCCT
GCTCTCTTGCCTGACCGTGCCCCGCTTCAGCCTACCAAGTGCGCAATTCTCGGG
GCTTTACCATGTACCAATGATTGCCCTAACTCGAGTATTGTGTACGAGGCGGC
CGATGCCATCCTGCACACTCCGGGGTGTGTCCCTTGCCTTCCGCGAGGGTAACG
CCTCGAGGTGTTGGGTGGCGGTGACCCCCACGGTGCCACCAAGGACGGCAA
ACTCCCCACAACGCAGCTTCGACGTCATATCGATCTGCTTGTGCGGAGCGCCA
CCCTCTGCTCGGCCCTCTACGTGGGGGACCTGTGCGGGTCTGTCTTTCTTGTG
GTCAACTGTTTACCTTCTCTCCAGGGCGCACTGGACGACGCAAGACTGCAATT
GTTCTATCTATCCCGGCCATATAACGGGTTCATCGCATGGCATGGGATATGATGA
TGAAGTGGTCCCCTACGGCAGCGTTGGTGGTAGCTCAGCTGCTCCGGATCCCA
CAAGCCATCATGGACATGATCGCTGGTGTCTACTGGGGAGTCTTGGCGGGCAT
AGCGTATTTCTCCATGGTGGGGAAGTGGGCGAAGGTCCTGGTAGTGCTGCTGC
TATTTGCCGGCGTCGACGCGGAAACCCACGTACCGGGGGGAAGTGCCGGCCG
CACCACGGCTGGGCTTGTGGTCTCCTTACACCAGGCGCCAAGCAGAACATCC
AACTGATCAACACCAACGGCAGTTGGCACATCAATAGCACGGCCTTGAAGTGC
AATGAAAGCCTTAACACCGGCTGTTAGCAGGGCTCTTCTATCAGCACAAATTC
AACTCTTCAGGCTGTCCTGAGAGGTTGGCCAGCTGCCGACGCTTACCGATTTT
GCCCAGGGCTGGGGTCTATCAGTTATGCCAACGGAAGCGGCCTCGACGAAC
GCCCCTACTGCTGGCACTACCCTCCAAGACCTTGTGGCATTGTGCCCGCAAAG
AGCGTGTGTGGCCCGGTATATTGCTTCACTCCCAGCCCCGTGGTGGTGGGAAC
GACCGACAGGTGCGGCGCGCCTACCTACAGCTGGGGTGCAAATGATACGGAT
GTCTTCGTCTTAACAACACAGGCCACCGCTGGGCAATTGGTTCGGTTGTACC
TGGATGAACTCAACTGGATTACCAAAGTGTGCGGAGCGCCCCCTTGTGTCTAT
CGGAGGGGTGGGCAACAACACCTTGTCTGCCCCACTGATTGTTTCCGCAAGC
ATCCGGAAGCCACATACTCTCGGTGCGGCTCCGGTCCCTGGATTACACCCAGG
TGCATGTTGACTACCCGTATAGGCTTTGGCACTATCCTTGTACCATCAATTAC
ACCATATTCAAAGTCAGGATGTACGTGGGAGGGGTGAGACAGGCTGGAAG
CGGCCTGCAACTGGACGCGGGGCGAACGCTGTGATCTGGAAGACAGGGACAG
GTCCGAGCTCAGCCCATTTGCTGCTGTCCACCACACAGTGGCAGGTCTTCCGT
GTTCTTTACGACCCTGCCAGCCTTGTCCACCGGCCTCATCCACCTCCACCAGA
ACATTGTGGACGTGCAGTACTTGTACGGGGTAGGGTCAAGCATCGCGTCTGG
GCCATTAAGTGGGAGTACGTCTGTTCTCCTGTTCTCCTGCTTGCAGACGCGCGC
GTCTGCTCCTGCTTGTGGATGATGTTACTCATATCCCAAGCGGAGGCGGCTTTG
GAGAACCTCGTAATACTCAATGCAGCATCCCTGGCCGGGACGCACGGTCTTGT
GTCTTCTCTCGTGTCTTCTGCTTTGCGTGGTATCTGAAGGGTAGGTGGGTGCC

FIGURE 26-1

Bicistronic HCV/BVDV chimera

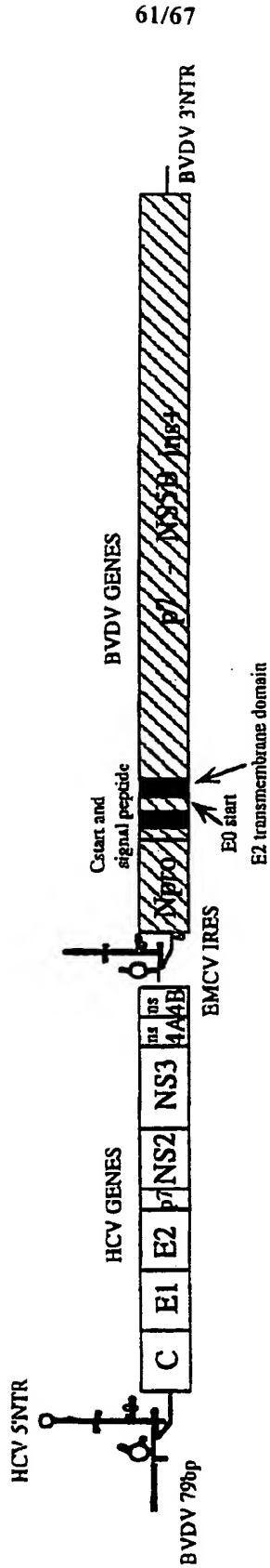


FIGURE 25

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GTCATGGGGGTTGGGACTGAGAGATACAAGTTAGGTCCCATAGTCAATCTGCT
 GCTGAGAAGGTTGAAAAATCTGCTCATGACGGCCGTCGGCGTCAGCAGCTGAg
 acaaaatgtatatattgtaataaataatccatgtacAATTCCGCCCTCTCCCTCCCCCCCCCTAACG
 TTA CTGGCCGAAGCCGCTTGGAATAAGGCCGGTGTGCGTTTGTCTATATGTTAT
 TTTCCACCATATTGCCGCTCTTTTGGCAATGTGAGGGCCCCGGA AACCTGGCCCTG
 TCTTCTTGAGCAGCATTCCTAGGGTCTTTCCCTCTCGCCAAAGGAATGCAAG
 GTCTGTTGAATGTCGTGAAGGAAGCAGTTCTCTGGAAGCTTCTTGAAGACAAA
 CAACGTCTGTAGCGACCCTTTGCAGGCAGCGGAACCCCCACCTGGCGCAGAG
 TGCCTCTGCGGCCAAAAGCCACGTGTATAAGATACACCTGCAAAGGCGGCACA
 ACCCCAGTGCCACGTTGTGAGTTGGATAGTTGTGGAAAGAGTCAAATGGCTCT
 CCTCAAGCGTATTCAACAAGGGGCTGAAGGATGCCCAGAAGGTACCCATTGT
 ATGGGATCTGATCTGGGGCCTCGGTGCACATGCTTTACATGTGTTTAGTCGAG
 GTTAAAAAACGTCTAGGCCCCCGAACCCACGGGGACGTGGTTTTCTTTGAAA
 AACACGATGATAAGCTTGCCACAACcattgaccgagtacaagcccacggtgctgcctcgccacccgacgacga
 cgtccccggggcgtacgcacctcgcgcgcggttcgccgactacccgccacgcgccacacgctgaccgcgaccgccacatc
 gagcgggtcaccgagctgcagaactcttctcacgcgcgtcgggctcgacatcgccaaggtgtgggtcgcggacgacggcgcc
 cgggtgcggtctcggaccacgcggagagcgtcggaagcgggggcggtgttctggccgagatcggcccgccatgcccgaagttag
 cggttccgcgtcggcgcgacgaacagatggaaggcctctggcgccgacccgccaagggagcccggtgtgtctcgtggccac
 cgtcggcgctcgcggcaccaccagggcgaaggctctgggcagcgcgcgtcgtgtccccggagtggaggcggcgccgagcgcgcg
 gggtgccccgcttctggagacctccgcgccccgcaacctccccctctacgagcggctcgggttcaccgtcaccgcccacgctc
 gcccgaaggaccgcgcgacctggtgcatgaccgcgaagcccggtgcTGAcgccccccccacgaccgcagcgcggcggaccg
 aaaggagcgcacgaccccatgaaATGCATCGATCGTACGAATTAACGCCGACAGGCTGATAT
 CCAGCAAACTGGCCACTTATACATACCTGATAAAGGCTTTACATTACAAGGAA
 AGCATTATGAGCAACTGCAGCTAAGAACAGAGACAAACCCGGTCATGGGGGTT
 GGGACTGAGAGATACAAGTTAGGTCCCATAGTCAATCTGCTGCTGAGAAGGTT
 GAAAATTTCTGCTCATGACGGCCGTCGGCGTCAGCAGCTGAacaaaaatgtatatattgtaataa
 aattaatccatgtacatagtgatatataatagttgggaccgtccacctcaagaagacgacgaccccaacacgcacagctaacaagtagt
 tcaagattatctacctcaagataaacactacattaatgcacacagcactttagctgtatgaggatagcccgacgctctatgttggactagg
 gaagacctctaacagcccc

FIGURE 24-5

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AAATACCCACCGCTACGGTCACCACATGGCTAGCTTACACCTTCGTGAATGAAG
ACGTAGGGACTATAAAACCAGTACTAGGAGAGAGAGTAATCCCCGACCCTGTA
GTTGATATCAATTTACAACCAGAGGTGCAAGTGGACACGTCAGAGGTTGGGAT
CACAATAATTGGAAGGGAAACCTGATGACAACGGGAGTGACACCTGTCTTGG
AAAAAGTAGAGCCTGACGCCAGCGACAACCAAACTCGGTGAAGATCGGGTTG
GATGAGGGTAATTACCCAGGGCCTGGAATACAGACACATACTAACAGAAGA
AATACACAACAGGGATGCGAGGCCCTTCATCATGATCCTGGGCTCAAGGAATT
CCATATCAAATAGGGCAAAGACTGCTAGAAATATAAATCTGTACACAGGAAATG
ACCCACAGGGAATACGAGACTTGATGGCTGCAGGGCGCATGTTAGTAGTAGCA
CTGAGGGATGTGACCCCTGAGCTGTCTGAAATGGTTCGATTTCAAGGGGACTTT
TTTAGATAGGGAGGCCCTGGAGGCTCTAAGTCTCGGGCAACCTAAACCGAAGC
AGGTTACCAAGGAAGCTGTTAGGAATTTGATAGAACAGAAAAAGATGTGGAG
ATCCCTAACTGGTTTGCATCAGATGACCCAGTATTTCTGGAAGTGGCCTTAAAA
AATGATAAGTACTACTTAGTAGGAGATGTTGGAGAGGTAAAAGATCAAGCTAA
AGCACTTGGGGCCACGGATCAGACAAGAATTATAAAGGAGGTAGGCTCAAGG
ACGTATGCCATGAAGCTATCTAGCTGGTTCCTCAAGGCATCAAACAAACAGATG
AGTTTAACTCCACTGTTTGAGGAATTGTTGCTACGGTGCCACCTGCAACTAAG
AGCAATAAGGGGCACATGGCATCAGCTTACCAATTGGCACAGGGTAAGTGGGA
GCCCCTCGGTTGCGGGGTGCACCTAGGTACAATACCAGCCAGAAGGGTGAAG
ATACACCCATATGAAGCTTACCTGAAGTTGAAAGATTTTCATAGAAGAAGAAGAG
AAGAAACCTAGGGTTAAGGATACAGTAATAAGAGAGCACAACAAATGGTACT
TAAAAAATAAGGTTTCAAGGAAACCTCAACACCAAGAAAAATGCTCAACCCTGG
GAAACTATCTGAACAGTTGGACAGGGAGGGGCGCAAGAGGAACATCTACAAC
CACCAGATTGGTACTATAATGTCAAGTGCAGGCATAAGGCTGGAGAAATTGCC
AATAGTGAGGGCCCAAACCGACACCAAAACCTTTCATGAGGCAATAAGAGATA
AGATAGACAAGAGTGAAAACCGGCAAAATCCAGAATTGCACAACAAATTGTTG
GAGATTTTCCACACGATAGCCCAACCCACCCTGAAACACACCTACGGTGAGGT
GACGTGGGAGCAACTTGAGGGCGGGGATAAATAGAAAGGGGGCAGCAGGCTTC
CTGGAGAAGAAGAACATCGGAGAAGTATTGGATTGAGAAAAGCACCTGGTAGA
ACAATTGGTCAGGGATCTGAAGGCCGGGAGAAAGATAAAATATTATGAACTG
CAATACCAAAAAATGAGAAGAGAGATGTGATGACTGGCAGGCAGGGGA
CCTGGTGGTTGAGAAGAGGCCAAGAGTTATCCAAATACCCTGAAGCCAAGACA
GGCTAGCCATCACTAAGGTCATGTATAACTGGGTGAAACAGCAGCCCGTTGTG
ATTCCAGGATATGAAGGAAAGACCCCTTGTTCACATCTTTGATAAAGTGAGA
AAGGAATGGGACTCGTTCAATGAGCCAGTGGCCGTAAGTTTGGACACCAAGC
CTGGGACACTCAAGTGACTAGTAAGGATCTGCACTTATTGGAGAAATCCAGA
AATATTACTATAAGAAGGAGTGGCACAAGTTCATTGACACCATCACCGACCACA
TGACAGAAGTACCAGTTATAACAGCAGATGGTGAAGTATATATAAGAAATGGG
CAGAGAGGGAGCGGCCAGCCAGACACAAGTGCTGGCAACAGCATGTTAAATG
TCCTGACAATGATGTACGCCTTCTGCGAAAGCACAGGGGTACCGTACAAGAGT
TTCAACAGGGTGGCAAGGATCCACGTCTGTGGGGATGATGGCTTCTTAATAAC
TGAAAAAGGGTTAGGGCTGAAATTTGCTAACAAGGGATGCAGATTCTTCATG
AAGCAGGCAAACCTCAGAAGATAACGGAAGGGGAAAAGATGAAAGTTGCCTAT
AGATTTGAGGATATAGAGTTCTGTTCTCATACCCAGTCCCTGTTAGGTGGTCC
GACAACACCAGTAGTCACATGGCCGGGAGAGACACCGCTGTGATACTATCAAA
GATGGCAACAAGATTGGATTCAAGTGGAGAGAGGGGTACCACAGCATATGAAA
AAGCGGTAGCCTTCAGTTTCTGTGCTGATGTATTCCTGGAACCCGCTTGTAGGA
GGATTTGCCTGTTGGTCCTTTGCAACAGCCAGAGACAGACCCATCAAAACATG
CCACTTATTATTACAAAGGTGATCCAATAGGGGCCTATAAAGATGTAATAGGTC
GGAATCTAAGTGAAGTGAAGAGAACAGGCTTTGAGAAATTGGCAAATCTAAAC
CTAAGCTGTCCACGTTGGGGATCTGGACTAAGCACACAAGCAAAAGAAATAT
TCAGGACTGTGTTGCCATTGGGAAAGAAGAGGGCAACTGGCTAGTTAACGCCG
ACAGGCTGATATCCAGCAAACTGGCCACTTATACATACCTGATAAAGGCTTTA
CATTACAAGGAAAGCATTATGAGCAACTGCAGCTAAGAACAGAGACAAACCCG

FIGURE 24-4

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CAAAAGCACCCAATAGAGGAATTCATAGCCCCGAGGTAATGAAAGGGGAGG
ATCTTGGTAGTCAGTTCCTTGATATAGCAGGGTTAAAAATACCACTGGATGAGA
TGAAAGGCAATATGTTGGTTTTTGTACCAACGAGAAACATGGCAGTAGAGGTA
GCAAAGAAGCTAAAAGCTAAGGGCTATAACTCTGGATACTATTACAGTGGAGA
GGATCCAGCCAATCTGAGAGTTGTGACATCACAATCCCCCTATGTAATCGTGCG
TACAAATGCTATTGAATCAGGAGTGACACTACCAGATTTGGACACGGTTATAGA
CACGGGGTTGAAATGTGAAAAGAGGGTGAGGGTATCATCAAAGATACCTTCA
TCGTAACAGGCCTTAAGAGGATGGCCGTGACTGTGGGTGAGCAGGCGCAGCG
TAGGGGCAGAGTAGGTAGAGTGAAACCCGGGAGGTATTATAGGAGCCAGGAA
ACAGCAACAGGGTCAAAGGACTACCACTATGACCTCTTGACAGGCACAAAGATA
CGGGATTGAGGATGGAATCAACGTGACGAAATCCTTTAGGGAGATGAATTACG
ATTGGAGCCTATACGAGGAGGACAGCCTACTAATAACCCAGCTGGAAATACTA
AATAATCTACTCATCTCAGAAGACTTGCCAGCCGCTGTAAAGAACATAATGGCC
AGGACTGATCAGGAGGCAATCCAACCTTGACATACAACAGCTATGAAGTCCA
GGTCCCGGTCCTGTTCCCAAAAATAAGGAATGGAGAAGTCACAGACACCTACG
AAAATTACTCGTTTCTAAATGCCAGAAAGTTAGGGGAGGATGTGCCCGTGTATA
TCTACGCTACTGAAGATGAGGATCTGGCAGTTGACCTCTTAGGGCTAGACTGG
CCTGATCCTGGGAACCAGCAGGTAGTGGAGACTGGTAAAGCACTGAAGCAAGT
GACCGGGTTGTCTCGGCTGAAAATGCCCTACTAGTGGCTTTATTTGGGTATGT
GGGTTACCAGGCTCTCTCAAAGAGGCATGTCCCAATGATAACAGACATATATAC
CATCGAGGACCAGAGACTAGAAGACACCACCCACCTCCAGTATGCACCCAACG
CCATAAAAACCGATGGGACAGAGACTGAACTGAAAGAACTGGCGTCGGGTGA
CGTGGAAAAAATCATGGGAGCCATTTAGATTATGCAGCTGGGGGACTGGAGT
TTGTTAAATCCCAAGCAGAAAAAGATAAAAAACAGCTCCTTTGTTTAAAGAAAACG
CAGAAGCCGCAAAAGGGTATGTCCAAAAATTCATTGACTCATTAAATTGAAAATA
AAGAAGAAATAATCAGATATGGTTTGTGGGGAACACACACAGCACTATACAAA
AGCATAGCTGCAAGACTGGGGCATGAAACAGCGTTTGCCACACTAGTGTAAA
GTGGCTAGCTTTTGGAGGGGAATCAGTGTGAGACCACGTCAAGCAGGCGGCA
GTTGATTTAGTGGTCTATTATGTGATGAATAAGCCTTCCTTCCAGGTGACTCC
GAGACACAGCAAGAAGGGAGGCGATTTCGTCGCAAGCCTGTTTCATCTCCGCACT
GGCAACCTACACATACAAAACCTTGAATTACCACAATCTCTCTAAAGTGGTGGA
ACCAGCCCTGGCTTACCTCCCTATGCTACCAGCGCATTAAAAATGTTACCCCC
AACGCGGCTGGAGAGCGTGGTGATACTGAGCACCACGATATATAAACACATACC
TCTCTATAAGGAAGGGGAAGAGTGATGGATTGCTGGGTACGGGGATAAGTGC
AGCCATGGAAATCCTGTCAAAAACCCAGTATCGGTAGGTATATCTGTGATGTT
GGGGGTAGGGGCAATCGCTGCGCACAACGCTATTGAGTCCAGTGAACAGAAA
AGGACCCTACTTATGAAGGTGTTTGTAAAGAACTTCTTGGATCAGGCTGCAACA
GATGAGCTGGTAAAAGAAAACCCAGAAAAAATTATAATGGCCTTATTTGAAGCA
GTCCAGACAATTGGTAACCCCTGAGACTAATATACCACCTGTATGGGGTTTAC
TACAAAGGTTGGGAGGCAAGGAACTATCTGAGAGGACAGCAGGCAGAAACT
TATTCACATTGATAATGTTTGAAGCCTTCGAGTTATTAGGGATGGACTCACAAG
GGAAAAATAAGGAACCTGTCCGGAATTACATTTTGGATTTGATATACGGCCTAC
ACAAGCAAATCAACAGAGGGCTGAAGAAAATGGTACTGGGGTGGGCCCTGC
ACCTTTTAGTTGTGACTGGACCCCTAGTGACGAGAGGATCAGATTGCCAACAG
ACAATATTTGAGGGTAGAAACCAGGTGCCCATGTGGCTATGAGATGAAAGCT
TTCAAAAATGTAGGTGGCAAACTTACCAAAGTGGAGGAGAGCGGGCCTTTCCT
ATGTAGAAACAGACCTGGTAGGGGACCAGTCAACTACAGAGTCACCAAGTATT
ACGATGACAACCTCAGAGAGATAAAACCAGTAGCAAAGTTGGAAGGACAGGTA
GAGCACTACTACAAAGGGGTACAGCAAAAATTGACTACAGTAAAGGAAAAAT
GCTCTTGGCCACTGACAAGTGGGAGGTGGAACATGGTGTGATAACCAGGTTAG
CTAAGAGATATACTGGGGTCCGGTTCAATGGTGCATACTTAGGTGACGAGCCC
AATCACCGTGCTCTAGTGGAGAGGGAGTGTGCAACTATAACCAAAAACACAGT
ACAGTTTCTAAAAATGAAGAAGGGGTGTGCGTTACCTATGACCTGACCATCTC
CAATCTGACCAGGCTCATCGAACTAGTACACAGGAACAATCTTGAAGAGAAGG

FIGURE 24-3

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GTCCTTCCTCGTGTTCTTCTGCTTTGCGTGGTATCTGAAGGGTAGGTGGGTGCC
CGGAGCGGTCTACGCCTTCTACGGGAAGTGGGTCTTACTCTTATACCACATCTT
AGTGGTACACCCAATCAAATCTGTAATTGTGATCCTACTGATGATTGGGGATGT
GGTAAAGGCCGATTACAGGGGGCCAAGAGTACTTGGGGAAAATAGACCTCTGTT
TTACAACAGTAGTACTAATCGTCATAGGTTTAATCATAGCTAGGCGTGACCCAA
CTATAGTGCCACTGGTAACAATAATGGCAGCACTGAGGGTCACTGAACTGACC
CACCAGCCTGGAGTTGACATCGCTGTGGCGGTCACTGACTATAACCCTACTGAT
GGTTAGCTATGTGACAGATTATTTTAGATATAAAAAATGGTTACAGTGCATTCTC
AGCCTGGTATCTGCGGTGTTCTTGATAAGAAGCCTAATATACCTAGGTAGAATC
GAGATGCCAGAGGTAACCTATCCCAAACCTGGAGACCACTAATTTAATACTATTA
TATTTGATCTCAACAACAATTGTAACGAGGTGGAAGGTTGACGTGGCTGGCCTA
TTGTTGCAATGTGTGCCTATCTTATTGCTGGTCACAACCTTGTGGGCCGACTTCT
TAACCCTAATACTGATCCTGCCTACCTATGAATTGGTTAAATTATACTATCTGAA
AAGTGTAGGACTGATACAGAAAGAAGTTGGCTAGGGGGGATAGACTATACAA
GAGTTGACTCCATCTACGACGTTGATGAGAGTGGAGAGGGCGTATATCTTTTC
CATCAAGGCAGAAAGCACAGGGGAATTTTCTATACTCTTGCCCTTATCAAAG
CAACACTGATAAGTTGCGTCAGCAGTAAATGGCAGCTAATATACATGAGTTACT
TAACCTTTGGACTTTATGTACTACATGCACAGGAAAGTTATAGAAGAGATCTCAG
GAGGTACCAACATAATATCCAGGTTAGTGGCAGCACTCATAGAGCTGAACTGG
TCCATGGAAGAAGAGGAGAGCAAAGGCTTAAAGAAGTTTATCTATTGTCTGG
AAGGTTGAGAAACCTAATAATAAAACATAAGGTAAGGAATGAGACCGTGGCTT
CTTGGTACGGGGAGGAGGAAGTCTACGGTATGCCAAAGATCATGACTATAATC
AAGGCCAGTACACTGAGTAAGAGCAGGCACTGCATAATATGCACTGTATGTGA
GGGCCGAGAGTGGAAGGTTGGCACCTGCCCAAATGTGGACGCCATGGGAAG
CCGATAACGTGTGGGATGTGCTAGCAGATTTTGAAGAAAGACACTATAAAAG
AATCTTTATAAGGGAAGGCAACTTTGAGGGTATGTGCAGCCGATGCCAGGGAA
AGCATAGGAGGTTTGAATGGACCGGGAACCTAAGAGTGCCAGATACTGTGCT
GAGTGTAAATAGGCTGCATCCTGCTGAGGAAGGTGACTTTTGGGCAGAGTCGAG
CATGTTGGGCCTCAAATCACCTACTTTGCGCTGATGGATGGAAGGTGTATGA
TATCACAGAGTGGGCTGGATGCCAGCGTGTGGGAATCTCCCCAGATACCCACA
GAGTCCCTTGTACATCTCATTTGGTTACCGGATGCCTTTCAGGCAGGAATACA
ATGGCTTTGTACAATATACCGCTAGGGGGCAACTATTTCTGAGAACTTGCCCG
TACTGGCAACTAAAGTAAAAATGCTCATGGTAGGCAACCTTGGAGAAGAAAT
GGTAATCTGGAACATCTTGGGTGGATCCTAAGGGGGCCTGCCGTGTGTGAAGAA
GATACAGAGCACGAAAAATGCCACATTAATACTGGATAAACTAACCGCATT
TTTCGGGATCATGCCAAGGGGGACTACACCCAGAGCCCCGGTGAGGTTCCCTA
CGAGCTTACTAAAAGTGAGGAGGGGTCTGGAGACTGCCTGGGCTTACACACAC
CAAGGCGGGATAAGTTCAGTCGACCATGTAACCGCCGGAAAAAGATCTACTGGT
CTGTGACAGCATGGGACGAACCTAGAGTGGTTTGCCAAAGCAACAACAGGTTGA
CCGATGAGACAGAGTATGGCGTCAAGACTGACTCAGGGTGCCAGACGGTGC
CAGATGTTATGTGTTAAATCCAGAGGCCGTTAACATATCAGGATCCAAAGGGG
CAGTCGTTACCTCCAAAAGACAGGTGGAGAATTCACGTGTGTCACCGCATCA
GGCACACCGGCTTTCTTCGACCTAAAAAATTTGAAAGGATGGTCAGGCTTGCCT
ATATTTGAAGCCTCCAGCGGGAGGGTGGTTGGCAGAGTCAAAGTAGGGAAGA
ATGAAGAGTCTAAACCTACAAAAATAATGAGTGAATCCAGACCGTCTCAAAAA
ACAGAGCAGACCTGACCGAGATGGTCAAGAAGATAACCAGCATGAACAGGGG
AGACTTCAAGCAGATTACTTTGGCAACAGGGGCAGGCAAAACACAGAACTCC
CAAAAGCAGTTATAGAGGAGATAGGAAGACACAAGAGAGTATTAGTTCTTATA
CCATTAAGGGCAGCGGCAGAGTCAGTCTACCAGTATATGAGATTGAAACACCC
AAGCATCTCTTTTAACTAAGGATAGGGGACATGAAAGAGGGGGACATGGCAA
CCGGGATAACCTATGCATCATACGGGTACTTCTGCCAAATGCCTCAACCAAAGC
TCAGAGCTGCTATGGTAGAATACTCATACATATTCTTAGATGAATACCAATTGTC
CACTCCTGAACAACTGGCAATTATCGGGAAGATCCACAGATTTTCAGAGAGTAT
AAGGGTTGTGCCATGACTGCCACGCCAGCAGGGTCCGTGACCACAACAGGT

FIGURE 24-2

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Gtatacagaattagaaaaggcactcgtatagctattgggcaattaaaaataataattaggcctaggtacatggcacgtgccagccccct
gatgggggacactccaccatgaatcactccccctgtgaggaaactactgtcttcacgcagaaagcgttagccatggcgttagtatgag
tgtcgtgcagcctccaggacccccctccccgggagagccatagtggtctcggaaccgggtgagtacaccggaattgccaggacgac
cgggtcctttcttgataaaccgctcaatgcctggagatttgggctgccccgcaagactgtagccgagtagtgggtcgcgaa
aggccttgggtactgcctgatagggtgctgagtgccccgggaggtctcgtagaccgtgcaccATGAGCACGAATC
CTAAACCTCAAAGAAAAACCAAACGTAACACCAACCGTCGCCCACAGGACGTC
AAGTTCCCGGGTGGCGGTACAGATCGTTGGTGGAGTTTACTTGTGTCGCGCAG
GGGCCCTAGATTGGGTGTGCGCGCAGCAGGAAGACTTCCGAGCGGTTCGCAA
CCTCGAGGTAGACGTCAGCCTATCCCCAAGGCACGTCGGCCCCGAGGGCAGGA
CCTGGGCTCAGCCCGGGTACCCTTGGCCCCCTCTATGGCAATGAGGGTTGCGGG
TGGGCGGGATGGCTCCTGTCTCCCCGTGGCTCTCGGCCTAGCTGGGGCCCCAC
AGACCCCCGGCGTAGGTTCGCGCAATTTGGGTAAAGTCATCGATAACCCTTACGT
GCGGCTTCGCGGACCTCATGGGGTACATACCGCTCGTCGGCGCCCCTCTTGGGA
GGCGCTGCCAGGGCCCTGGCGCATGGCGTCCGGGTTCTGGAAGACGGCGTGA
ACTATGCAACAGGGAACCTTCTGTTGCTCTTTCTCTATCTTCTTCTGGCCCT
GCTCTCTTGCTGACCGTGCCCGCTTCAGCCTACCAAGTGCGCAATTCCTCGGG
GCTTTACCATGTCACCAATGATTGCCCTAACTCGAGTATTGTGTACGAGGCGGC
CGATGCCATCCTGCACACTCCGGGGTGTGTCCCTTTCGTTTCGCGAGGGTAACG
CCTCGAGGTGTTGGGTGGCGGTGACCCCCACGGTGGCCACCAGGGACGGCAA
ACTCCCCACAACGCAGCTTCGACGTCATATCGATCTGCTTGTTCGGGAGCGCCA
CCCTCTGCTCGGCCCTCTACGTGGGGGACCTGTGCGGGTCTGTCTTTCTTGTG
GTCAACTGTTTACCTTCTCTCCAGGCGCCACTGGACGACGCAAGACTGCAATT
GTTCTATCTATCCCGGCCATATAACGGGTTCATCGCATGGCATGGGATATGTA
TGAAGTGGTCCCCTACGGCAGCGTTGGTGGTACTGCTCAGCTGCTCCGGATCCCA
CAAGCCATCATGGACATGATCGCTGGTGTCACTGGGGAGTCTTGGCGGGCAT
AGCGTATTTCTCCATGGTGGGGAACCTGGGCGAAGGTCCTGGTAGTGCTGCTGC
TATTTGCCGGCGTCGACGCGGAAACCCACGTCACCGGGGGAAGTGCCGGCCG
CACCACGGCTGGGCTTGTGTTGCTCCTTACACCAGGCGCCAAGCAGAACATCC
AACTGATCAACACCAACGGCAGTTGGCACATCAATAGCACGGCCTTGAAGTGC
AATGAAAGCCTTAACACCGGCTGGTGTAGCAGGGCTCTTCTATCAGCACAAATTC
AACTCTTCAGGCTGTCTGAGAGGTTGGCCAGCTGCCGACGCCTTACCGATTTT
GCCCAGGGCTGGGGTCTATCAGTTATGCCAACGGAAGCGGCCTTCGACGAAC
GCCCCTACTGCTGGCACTACCTCCAAGACCTTGTGGCATTGTGCCCAGAAAG
AGCGTGTGTGGCCCGGTATATTGCTTCACTCCCAGCCCCGTGGTGGTGGGAAC
GACCGACAGGTTCGGGCGCGCCTACCTACAGCTGGGGTGCAAATGATACGGAT
GTCTTCGTCCTTAACAACACCAGGCCACCGCTGGGCAATTGGTTTCGGTTGTACC
TGGATGAACTCAACTGGATTACCAAAGTGTGCGGAGCGCCCCCTTGTGTCTAT
CGGAGGGGTGGGCAACAACACCTTGTCTGCCCCACTGATTGTTTCCGCAAGC
ATCCGGAAGCCACATACTCTCGGTGCGGCTCCGGTCCCTGGATTACACCCAGG
TGCATGGTTCGACTACCCGTATAGGCTTTGGCACTATCCTTGTACCATCAATTAC
ACCATATTCAAAGTCAGGATGTACGTGGGAGGGGTCGAGCACAGGCTGGAAG
CGGCGTGAACCTGGACGCGGGGCAACGCTGTGATCTGGAAGACAGGGACAG
GTCCGAGCTCAGCCCAATTGCTGCTGTCCACCACACAGTGGCAGGTCTTCCGT
GTTCTTTCACGACCCTGCCAGCCTTGTCCACCGGCCTCATCCACCTCCACCAGA
ACATTGTGGACGTGCAGTACTTGTACGGGGTAGGGTCAAGCATCGCGTCTTGG
GCCATTAAGTGGGAGTACGTCGTTCTCCTGTTCTCCTGCTTGCAGACGCGCGC
GTCTGCTCCTGCTTGTGGATGATGTTACTCATATCCCAAGCGGAGGGCGGCTTTG
GAGAACCTCGTAATACTCAATGCAGCATCCCTGGCCGGGACGCACGGTCTTGT

FIGURE 24-1

HCV/BVDV chimera with selectable marker

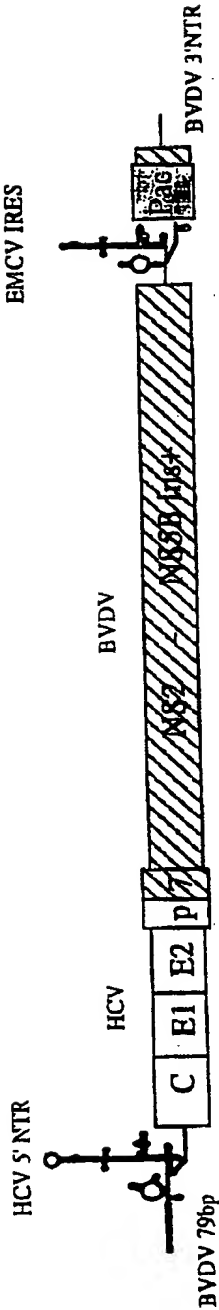


FIGURE 23

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AAGGTTGAAAATTCTGCTCATGACGGCCGTCGGCGTCAGCAGCTGAgacaaaatgtat
atattgtaataaattaatccatgtacatagtgtatataaatatagttgggaccgtccacctcaagaagacgacagcccaacacgcacag
ctaaacagtagtcaagattatctacctcaagataacactacattaatgcacacagcacittagctgtatgaggatacggcgacgtctatag
ttggactaggggaagacctctaagcccc

FIGURE 22-5

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ACGTAGGGACTATAAAACCAGTACTAGGAGAGAGAGTAATCCCCGACCTGTG
GTTGATATCAATTTACAACCAGAGGTGCAAGTGGACACGTGACAGGTTGGGAT
CACAATAATTGGAAGGGAAACCCTGATGACAACGGGAGTGACACCTGTCTTGG
AAAAAGTAGAGCCTGACGCCAGCGACAACCAAAACTCGGTGAAGATCGGGTTG
GATGAGGGTAATTACCCAGGGCCTGGAATACAGACACATACTAACAGAAGA
AATACACAACAGGGATGCGAGGCCCTTCATCATGATCCTGGGCTCAAGGAATT
CCATATCAAATAGGGCAAAGACTGCTAGAAATATAAATCTGTACACAGGAAATG
ACCCCAGGGAAATACGAGACTTGATGGCTGCAGGGCGCATGTTAGTAGTAGCA
CTGAGGGATGTCGACCCTGAGCTGTCTGAAATGGTTCGATTTCAAGGGGACTTT
TTTAGATAGGGAGGCCCTGGAGGCTCTAAGTCTCGGGCAACCTAAACCGAAGC
AGGTTACCAAGGAAGCTGTTAGGAATTTGATAGAACAGAAAAAGATGTGGAG
ATCCCTAACTGGTTTGCATCAGATGACCCAGTATTTCTGGAAGTGCGCTTAAAA
AATGATAAGTACTACTTAGTAGGAGATGTTGGAGAGCTAAAAGATCAAGCTAAA
GCACTTGGGGCCACGGATCAGACAAGAATTATAAAGGAGGTAGGCTCAAGGA
CGTATGCCATGAAGCTATCTAGCTGGTTCCTCAAGGCATCAAACAAACAGATGA
GTTTAACTCCACTGTTTGAGGAATTTGTTGCTACGGTGCCACCTGCAACTAAGA
GCAATAAGGGGACATGGCATCAGCTTACCAATTGGCACAGGGTAAGTGGGAG
CCCCTCGGTTGCGGGGTGCACCTAGGTACAATACCAGCCAGAAGGGTGAAGAT
ACACCCATATGAAGCTTACCTGAAGTTGAAAGATTTTCATAGAAGAAGAAGAGAA
GAAACCTAGGGTTAAGGATACAGTAATAAGAGAGCACAAACAAATGGATACTTA
AAAAATAAGGTTTCAAGGAAACCTCAACACCAAGAAAATGCTCAACCCAGGG
AACTATCTGAACAGTTGGACAGGGAGGGGCGCAAGAGGAACATCTACAACCA
CCAGATTGGTACTATAATGTCAAGTGCAGGCATAAGGCTGGAGAAATTGCCAA
TAGTGAGGGCCCAAACCGACACCAAAACCTTTCATGAGGCAATAAGAGATAAG
ATAGACAAGAGTGAAAACCGGCAAAATCCAGAATTGCACAACAAATTGTTGGA
GATTTTCCACACGATAGCCCAACCCACCCTGAAACACACCTACGGTGAGGTGA
CGTGGGAGCAACTTGAGGCGGGGGTAAATAGAAAGGGGGCAGCAGGCTTCCT
GGAGAAGAAGAACATCGGAGAAGTATTGGATTGAGAAAAGCACCTGGTAGAAC
AATTGGTCAGGGATCTGAAGGCCGGGAGAAAGATAAAATATTATGAACTGCA
ATACCAAAAAATGAGAAGAGAGATGTCAGTGATGACTGGCAGGCAGGGGACC
TGGTGGTTGAGAAGAGGGCCAAGAGTTATCCAATACCCTGAAGCCAAGACAAGG
CTAGCCATCACTAAGGTCATGTATAACTGGGTGAAACAGCAGCCCGTTGTGATT
CCAGGATATGAAGGAAAGACCCCTTGTTCACATCTTTGATAAAGTGAGAAAAG
GAATGGGACTCGTTCAATGAGCCAGTGGCCGTAAGTTTTGACACCAAAGCCTG
GGACACTCAAGTGACTAGTAAGGATCTGCAACTTATTGGAGAAATCCAGAAATA
TTACTATAAGAAGGAGTGGCACAAGTTTATTGACACCATCACCGACCACATGAC
AGAAGTACCAGTTATAACAGCAGATGGTGAAGTATATATAAGAAATGGGCAGA
GAGGGAGCGGCCAGCCAGACACAAGTGCTGGCAACAGCATGTTAAATGTCCT
GACAATGATGTACGGCTTCTGCGAAAGCACAGGGGTACCGTACAAGAGTTTCA
ACAGGGTGGCAAGGATCCACGTCTGTGGGGATGATGGCTTCTTAATAACTGAA
AAAGGGTTAGGGCTGAAATTTGCTAACAAAGGGATGCAGATTCTTCATGAAGC
AGGCAAACCTCAGAAGATAACGGAAGGGGAAAAGATGAAAGTTGCCATAGAT
TTGAGGATATAGAGTTCTGTTCTCATACCCAGTCCCTGTTAGGTGGTCCGACA
ACACAGTAGTCACATGGCCGGGAGAGACACCGCTGTGATACTATCAAAGATG
GCAACAAGATTGGATTCAAGTGGAGAGAGGGGTACCACAGCATATGAAAAAGC
GGTAGCCTTCAGTTTCTTGCTGATGTATTCTGGAACCCGCTTGTAGGAGGAT
TTGCCTGTTGGTCCTTTCGCAACAGCCAGAGACAGACCCATCAAACATGCCAC
TTATTATTACAAAGGTGATCCAATAGGGGCCTATAAAGATGTAATAGGTCCGAA
TCTAAGTGAAGTGAAGAGAACAGGCTTTGAGAAATTGGCAAATCTAAACCTAAG
CCTGTCCACGTTGGGGGTCTGGAATAAGCACACAAGCAAAAGAAATTAATTCAGG
ACTGTGTTGCCATTGGGAAAGAAGAGGGCAACTGGCTAGTTAAGCCCGACAGG
CTGATATCCAGCAAACTGGCCACTTATACATACCTGATAAAGGCTTTACATTAC
AAGGAAAGCATTATGAGCAACTGCAGCTAAGAACAGAGACAAACCCGGTCATG
GGGTTGGGACTGAGAGATAAAGTTAGGTCCCATAGTCAATCTGCTGCTGAG

FIGURE 22-4